The Implementation of Climate Change Adaptation Policies to Increase the Resilience of Road Transport Sector

Mr. Amir Eghbalighazijahani

MSc. in Civil & Environmental Engineering
BSc. in Civil Engineering

Faculty of Art, Design and the Built Environment
University of Ulster

July, 2016

A thesis submitted in partial fulfilment of the requirements of the University of Ulster for the degree of Doctor of Philosophy (PhD)

I confirm that the word count of this thesis is less than 100,000 words

Table of Contents

Summary

In spite of growing interest in response to climate change by reducing greenhouse gas emission in transport sector, scientists and politicians have not paid enough attention to climate change adaptation in transport sector in recent decades. On the other hand, in the context of climate change adaptation, most studies are concerned about climate change impacts and the assessment of those impacts. Previous studies show that in spite of the importance of road transport sector on UK economy, this sector was not successful enough in delivering the national climate change adaptation policies on the ground.

This study investigates the effectiveness of transport governance arrangements in the implementation and delivery of climate change adaptation policies. This research employs a mixed method approach using a multiple case study design. Considering different factors affecting the effectiveness of policy implementation in transport sector, two case study areas i.e. Belfast and Cambridge were judged to be the most useful. The qualitative part of the research uses case study and semi-structured interviews. Then, using the findings from the interviews, the Q methodology is used to quantitatively analyse and compare attitudes of different stakeholders regarding the barriers against the implementation of climate change adaptation policies in road transport sector.

Findings show that Belfast and Cambridge are facing different barriers against the implementation of climate change adaptation policies in road transport sector. Participants in Belfast raised their concerns mostly about the lack of political will and support, lack of joined up thinking and inappropriate financial mechanism. On the other hand, participants in Cambridge emphasised on the lack of financial resources, guidelines and standards at the national level. However, the results analysis suggests that almost all participants have used the same platforms to raise their concerns about those barriers i.e. uncertainty about climate change impacts,

the long-term nature of climate change, differing party-political interests and the lack of public awareness on climate change.

It can be concluded that when a top-down model is used for the implementation of climate change adaptation policies, it is crucial to establish an independent organisation to advice different stakeholders on the integration of climate change adaptation policies in relation with transport policies in order to minimise the impacts of uncertainties and the lack of political support. However, when a bottom-up model is used, the national government needs to support local level stakeholders with detailed guidelines and long-term sustainable transport plans which take into account financial constraints at the local level.

Acknowledgment

First and foremost, my very special appreciation and thanks must go to my wife. Somayeh, you are tremendous. To be honest, I could not finish this thesis without all your help, support, encouragement and kindness. I must just say a big Damet Garm.

My special thanks go to my supervisors. Professor Julian Hine. Many thanks for all your patient guidance, advices and support during my PhD. you helped me grow as a researcher and I learned a lot from you which are already helping me in my life and career. Dr Lisa Davison, I was very lucky that you became my supervisor. Many thanks for all your supports and advices, they contributed enormously to the production of this thesis. Dr Anil Kashyap and Dr Lesley Hemphill, I wish to express my gratitude for your advices during my PhD.

I gratefully thank to all those individuals and professionals who participated in interviews and surveys conducted for this research. This thesis was not completed without you. Your comments and information contributed significantly to this thesis. Many thanks.

I would like to thank my thesis examination committee, Professor John Preston, Dr Neale Blair and Professor Jim Berry for the inspiring discussion during the viva and all their comments that helped to improve this thesis.

I gratefully express my gratitude to Heather Law, Cathy McMorris, Nicola Dunbar and Auriol Sudlow for providing timely support in various aspects of my research study. My special thanks to my colleagues and friends, Babak Zarei Farid Arya, Houman Atefi, Urbi Banerjee and Waseem Akram for their help and valuable contributions to this research. I also wish to express my sincere gratitude to the University of Ulster for funding my studies.

At last but not least, my special thanks go to my parents and family. Many thanks for a huge amount of support you have given right to the end of my study. Sagholasuz.

Note on Access to Contents

List of Figures

List of Tables

Chapter 1 - Introduction

1.1 Introduction

Climate change has become a serious global issue. Globally two fundamental strategies are employed to address the climate change challenge i.e. mitigation and adaptation. Mitigation, also known as decarbonisation, aims to decrease the cause of climate change through decreasing greenhouse gas emissions (IPCC, 2014b, IPCC, 2014a). Examples in the transport sector are a modal shift from private car use to sustainable modes of transport such as walking, cycling and public transports (Chapman, 2007).

In the early stages of the climate change problem, the reduction of GHG emissions (mitigation) was identified as the most effective response to this global threat. The Earth Summit (UNFCCC, 1992), and Kyoto Protocol (UNFCCC, 1997) were the two main international attempts to address the climate change through mitigation. The aim was to reduce the greenhouse gas emissions produced by all parties with emphasis on developed countries. Several measures were taken by governments to reduce the amount of greenhouse gases emitted from different sectors. In the transport sector, employing new fuel technology options, motivating people to use public transport and non-motorised modes of transport (walking and cycling) were the main measures for climate change mitigation. UNFCCC's yearly conferences on climate change, known as COPs (Conference of the Parties), has started from 1995 (2 years before Kyoto Protocol). Although more countries have joined as the parties to reduce the amount of their greenhouse gas emissions, still there are many political barriers in achieving a sustainable climate change mitigation agreement. For example, in COP 25, held in Paris, main parties (including USA) reached an agreement on the level of greenhouse gas emission reductions by parties. But then in 2017, USA's new president called it a mistake.

Adaptation, on the other hand, aims to fit vulnerable systems to the new climatic conditions. Researches and activities in the climate change mitigation were started far sooner than the adaptation as both scientists and politicians realized that stopping the cause is better than repairing the results (Boyd et al., 2011). It is becoming clear that even a good level of mitigation cannot avoid the future impacts of the climate change (IPCC, 2007a), it was then accepted by governments that achieving sustainable development and having a resilient society are not possible without paying proper attention to the adaptation (IPCC, 2007a, IPCC, 2014a, Berrang-Ford et al., 2015). This research focuses on the climate change adaptation with a particular emphasis on investigating the impact of transport governance arrangements in the implementation and delivery of the climate change adaptation policies.

The Intergovernmental Panel on Climate Change (IPCC) argues the importance of climate change adaptation to address the unavoidable impacts of climate change (IPCC, 2014a). According to Climate Change Risk Assessment, CCRA, (DEFRA, 2012c), the UK will experience hotter summers and wetter winters in the next decades. This, in turn, will affect different sectors, including transport infrastructures and services (Walker et al., 2014, DEFRA, 2012f). CCRA shows that the transport sector in the UK is at the risk of excessive winter rainfall, flooding, high summer temperatures and landslides.

Urban areas and urban transport infrastructures are at the heart of climate change adaptation debates. On the one hand, in the developed and developing countries, the population of the urban areas increases year by year and these expansions demand more transport infrastructures. On the other hand, most everyday life activities are connected to the effectiveness of the transport network. Currently, more than half the world's population are living in urban areas (UN-Habitat, 2011). This figure is even higher for developed countries (UN, 2007). In the UK, urban areas provide habitats for more than 82% of the total population (World-Bank, 2014). From the climate change mitigation perspective, globally, urban areas are responsible for more than 70% of greenhouse emissions (UN-Habitat, 2011); and from the adaptation perspective the concentration of population, business activities and infrastructures make urban areas more vulnerable to the impacts of the climate change (Castán Broto and Bulkeley, 2013).

The UK is a road dependant society; the road transport is responsible for 93% of all UK passenger kilometres of travel and 88% of inland freight journeys (DEFRA, 2012c). The crucial role of a reliable transport system for economic growth has been highlighted in different studies (Headicar, 2009, CFIT, 2010). The literature shows that the road transport performs worse under extreme weather condition, and in turn, this can influence the performance of other sectors (Walker et al., 2014, Chinowsky et al., 2013). Although the Eddington Transport Study (2006) does not clearly discuss the climate change impacts and adaptations, it argues that the main challenge for the government in the transport sector is to enhance the performance of the existing network. In the context of the transport sector, to a greater extent, the climate change adaptation is about enhancing the performance by adjusting the system to adopt new climatic conditions. Although the climate change impacts are not 'new' risks, but they represent a 'change' to existing risks (DEFRA, 2012g). From this perspective, the climate change can be seen as a factor which imposes some risks on the level of performance, or can change the outcomes of the non-climate policies including transport policies. For example, the projected extreme weather can persuade the cyclists to use private cars (Winters et al., 2007). And this is in contrast with the UK's increasing emphases on sustainable transport (DCLG, 2012, DETR, 1998, DFT, 2011a).

The UK Government published the Climate Change Act (CCA) in 2008. In addition to the setting of binding targets for the mitigation, CCA introduced a new "Adapting to Climate Change" (ACC) Programme (DEFRA, 2013) to address the climate change impacts in the UK which developed a statutory framework and urged the UK government to develop and implement appropriate climate change adaptation programmes (Parliament, 2008). Since, the adaptation is a devolved matter (Termeer et al., 2011), three devolved administrative areas (Northern Ireland , Scotland and Wales) develop their own frameworks to address the risks of climate change (Scotland, 2009, Welsh-Assembly, 2010b, DOENI, 2014). Transport departments in the UK and the three devolved administrative areas then implemented the national adaptation strategies to the departmental adaptation policies and action plans (DFT, 2011b, DFT, 2010a, Scotland, 2011).

However, despite the vulnerability of the transport sector against the climate change impacts, Tompkins et al. (2010) indicates that the UK's transport sector has largely remained outside the sphere of adaptation activities. Globally, the main contribution of the transport sector to tackle the climate change is the mitigation of greenhouse gas emissions such as reducing car dependency and increasing the number of walking and cycling trips (Chapman, 2007, Bulkeley et al., 2011). Bulkeley et al. (2011, p.152) argues that in the UK "*action on climate adaptation has remained marginal and usually a secondary impact of policies designed to tackle other urban problems*". On the other hand, the majority of transport studies, even in recent years, in the context of climate change adaptation, have focused on the impact assessment of the transport system (Rattanachot et al., 2015, Strauch et al., 2015, Mitsakis et al., 2014). Arnell (2010) argues that there is not enough research conducted to investigate the role of decision-making process on the transport sector with respect to climate change adaptation policies. Focusing on the road transport sector, this study is concerned with the implementation of the climate change adaptation policies and the integration of these policies with road transport strategies and governance.

The important role of effective governance arrangements in the implementation and the delivery of transport policies and objectives has been emphasised in numerous research studies (Eddington, 2006, Docherty and Shaw, 2009, Marsden and Rye, 2010, Pemberton, 2000, Marsden and May, 2006, Walker et al., 2014). The UK is a multi-level polity and decision-making where implementation and integration of the climate change adaptation and transport policies take place across multiple spatial levels with a large number of actors (Bulkeley, 2009, Marsden and Rye, 2010). As a result, governing the transport sector adaptation to the impacts of climate change is problematic mainly because of the multitude of actors involved at different levels, and also because of their interdependencies and varying interests that impede consensus and lead to sub-optimal outcomes of negotiations (Fröhlich and Knieling, 2013, Gupta, 2007b).

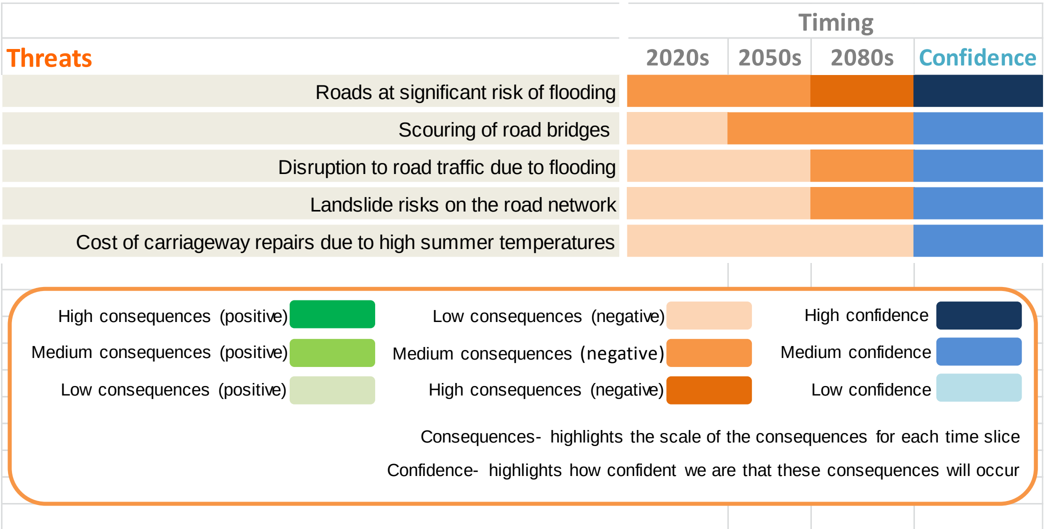
This research is undertaken to find out to what extent the existing governance arrangements can facilitate the climate change adaptation in designing and implementation of policies. In particular, it emphasises the differences between the transport governance arrangements employed within the UK's distinct devolved jurisdictions. The expected outcome of this comparative case study research is to assess different viewpoints and attitudes of transport stakeholders about the effectiveness of the existing governance arrangements in adopting and translating the national climate change adaptation policies into local initiatives and actions. To do so, the research will evaluate the barriers that the different transport stakeholders at local levels are facing during the implementation and delivery of national climate change adaptation policies. The main themes around the governance of climate change adaptation in the literature, including accountability, transparency, participation and coordination (see chapter 2 for more details) will be evaluated to assess how these factors influence the effectiveness of the road transport sector to tackle climate change impacts.

1.2 Effects of the Climate Change on Road Transport

According to Climate Change Risk Assessment (DEFRA, 2012c, DEFRA, 2012d), climate change will have negative impacts on road transportation infrastructures and the operations. Recent evidences of the climate change impacts on the UK's transport infrastructures are available. For example, summer floods of 2007 in Gloucestershire affected many roads which resulted in key workers being unable to get into work (DEFRA, 2012c). Heavy snow across England cities in the last decade has caused road chaos and accidents (Thornes, 2005, Andersson and Chapman, 2011). According to Thornes (2005), due to the infrequency of snow-related problems, the UK's road network is under-prepared, although two cold winters of 2009-2010 and 2010-2011 have increased the attention on winter resilience (DFT, 2010b).

DEFRA (DEFRA, 2012c) published "Climate Change Risk Assessment: Transport" which identified the most important impacts of climate change on road transport system (Table 1-1). However, according to the literature, not all of the impacts of the climate change are negative for transportation. Climate change will also have some positive influence on this sector. For example, transport construction activities will benefit from increasing the period of the warm weather (DEFRA, 2012c). Reduction in the number of accidents in winter and reduction of the salt use during winter, due to decreasing the severity of winter season, are two positive impacts of climate change for the transport sector (Andersson and Chapman, 2011). However, Andersson and Chapman (2011) argue that a warmer climate may cause a budget cut for maintenance of the road transport network which in turn can decrease the resilience of UK's road to climate change impacts.

Table 1-1: Impacts of climate change on road transport



Source: (DEFRA, 2012d)

Globally, most of the climate change impacts on the transport sector are the result of an increase in global temperature, heat waves, sea level rise, change in precipitation patterns and an increase in the intensity of hurricanes (Koetse and Rietveld, 2012, Koetse and Rietveld, 2009, Turnbull et al., 2011, TRB, 2008). On the other hand, it is not possible to assess climate change impacts on the road transport sector without considering the inter-sectorial relationships. Increasing the average temperature could result in changes in the international travel patterns; this would change due to the changes in the suitable time and places for tourist travels (Koenig and Abegg, 1997). According to DEFRA (2012e), warmer climates in the UK may cause the establishment of new tourist attractions or the expansion of the current ones. In addition, changing temperature will change the agriculture production patterns in different countries (Olesen and Bindi, 2002, IPCC, 2007a) which can change the freight transport patterns. As a result, UK's road infrastructures should be adjusted to this new demand. Furthermore, as discussed further in Chapter 2, uncertainty about the climate change and its impacts makes the process of decision making more problematic. As shown in Table 1-1, there are different levels of confidence about the projected impacts.

Hence, transport decision makers are facing a challenging situation in planning a transport project which may be operational for more than 100 years.

Although sea level rise is not an urgent matter between European countries (Hanson et al., 2011), studies shows that this phenomenon can have substantial effects on transport infrastructure in the coastal areas due to the increasing the risk of flooding (Hallegatte et al., 2011, Kleinosky et al., 2007, Koetse and Rietveld, 2009). These impacts cannot only harm the transport infrastructure, but they can also impose further social costs to the system by delaying or changing travel routes. Road infrastructures in the coastal areas of the UK are likely to experience combined river and tidal floods. According to 'Resilience of UK Infrastructure' (Parliament, 2010), a high proportion of transport infrastructures are located in coastal areas. This report indicates that most transport operators have not adapted their networks and have accepted some interruption of service as the most cost-effective for flood management. Hence, sea level rise can prevent river runoff discharging into the sea especially when storm conditions create high tides (Few et al., 2007). According to Penning-Rowsell et al. (2014), the M1 motorway's closure (between junction 31 and 34) for two days in 2007, as a result of the danger of dam break at Ulley reservoir, has caused £2.3 million disruption costs. This report estimates the total cost (infrastructure damage and traffic delay) of the UK's flooding in 2007 on road transport to be £191 million and almost half of this cost is related to the direct traffic disruption.

In addition to the flooding, landslide and other direct impacts of climate change on the transport infrastructure, climate change can have other significant impacts on the road transport network through changing the behaviour of the people from green modes of transport to individual car use. The literature shows that travelling through congested areas under adverse weather condition reduces vehicle speed by about 7% (Sabir et al., 2011). Some predictions argue that this impact has the potential to double the delays and lost trips (Suarez et al., 2005). Moreover, the change in the precipitation pattern, and consequently congestion, have been mentioned as one of the most important variables for road traffic safety (Andrey et al., 2001, Chung et al., 2005). Precipitation increases the risk of the road accident in frequency but decreases the risk in terms of severity (Koetse and Rietveld, 2012).

Modal shift, route change and earlier departure time change are other impacts of climate change which may cause infrastructure disruptions and can negatively affect sustainable transport (Koetse and Rietveld, 2009, Khattak and De Palma, 1997). For example, Winters et al. (2007) cites that the local climatic weather condition as an influential factor in deciding to cycle i.e. with more precipitation and lower temperature it is more likely to result in lower levels of cycling. As a result, increased temperature during summer time can be a motivator for the UK's residents to consider non-motorised modes, conversely, increased precipitation during the winter acts as an obstacle that may cause a modal shift from green modes of transport such as walking and cycling to other modes (Brandenburg et al., 2007, Nankervis, 1999). An empirical study in the Netherlands by Sabir et al. (2008) also shows that in low temperatures cyclists will switch to private car and public transport modes, but most of them will use private cars in precipitation conditions. Sabir et al. (2008) confirm the findings of previous literature, but they argue that cyclists will again switch to car or public transport when the temperature becomes more than 25 degrees Celsius. Hence, it is important to consider the climate change in the planning of road transport projects not only for assessing the direct impacts and potential damages to infrastructure, but also for integrating the aims of sustainable transport policies with the indirect impacts of the climate change on different modes of transportation. The existing body of literature indicate that climate change impacts cannot be assessed and addressed reactively. A proactive approach is required instead which encompasses an integrated risk assessment which acknowledges the multi-sectoral and cross-boundary characteristics of the climate change (Fröhlich and Knieling, 2013).

1.3 Complex Process of Climate Change Adaptation

In the context of the public policy, Sabatier (2007, 1991) argues that the planning process is complex because development and implementation of a policy involves numerous actors and interest groups across different levels of government. In addition, policy development and implementation often involves time frames of a decade or more to apply the relevant legislation into action (Sabatier, 1986). Moreover, because of resource limitation, stakeholders need to prioritise between different interrelated programs that they are responsible for, which can impact on the policy effectiveness.

Sabatier's (2007, 1991) rationale about the complexity of the planning process is in consistent with the problems identified by scholars in the field of climate change policies (Fröhlich and Knieling, 2013, Waters et al., 2014, Termeer et al., 2013). For example, according to Burton (2009) and Fröhlich and Knieling (2013), the climate change is a challenging policy area; because:

1) Climate change represents a set of linked problems. Hence, many actors involved in the process of climate change adaptation have different interests, attitudes and priorities towards the problem.
2) It is difficult to estimate the short-term and long-term costs and benefits of climate change. The inherent uncertainty of the climate change impedes the systematic planning and consequently affects the definition of the policy objectives and allocation of financial resources. These factors in turn can impede the transparency and accountability of the decision making process.
3) Climate change impacts are not aligned to the administrative boundaries, therefore integrating climate change planning into the process of formal decision making will be problematic.
4) Climate change is a multi-level and cross-sectoral problem.

5) It is difficult to allocate responsibility for climate change and provide resources to address some major issues, such as equity, appropriateness, etc.
6) There is not unanimous instrument to respond to climate change.

Furthermore, the transport sector itself is a challenging policy sector because it does not respect administrative boundaries and needs to be considered at all governmental levels (Marsden and Rye, 2010, Kane and Del Mistro, 2003). The literature expands on some of the difficulties faced by transport decision makers including the long-term planning horizons (about 100 years) and complex interfaces, the conflicting interests between different actors involved in the process, difference in project scope and level of ambition over time, and misinformation about costs, benefits and risks (Rajé, 2007, Cantarelli et al., 2012, Flyvbjerg, 2007).

1.4 The Role of Governance in Climate Change Adaptation

Breen and Anderies (2011), defined 'governance' as the collection of organisational structures and institutions that together form a mechanism by which decisions are made and implemented. Fröhlich and Knieling (2013) define governance as the softer forms of regulation and government wherein problems are solved through inclusion of private stakeholders into the hierarchical government decisions. Hence, analysing governance takes into account both formal and informal actors. For Stoker (1998), the concept of governance has different meanings and applications. He argues that governance perspective is a "simplifying lens to a complex reality … and provides a language in which to identify key features of a complex reality and also to pose significant questions about the reality" (Stoker, 1998, p. 26). Stoker's viewpoint about the governance, provides a unique conceptual framework for investigating the multiple and various relationship which exists within climate change adaptation governance. As discussed in

Section 1.3, the process of development and implementation of climate change adaptation policies in the UK involves a variety of actors at different levels. Hence, the conceptual framework of governance can benefit this research through mapping the actors, their relationships and effectiveness of the coordination among the actors involved in the climate change adaptation mechanism.

Adapting to climate change impacts can be constrained due to many institutional factors such as weak coordination and unclear division of responsibilities between different actors involved in the process of climate policy transition (Gupta, 2007a). As a result, focusing only on the exposure of urban areas to environmental hazards is not sufficient, but attention to the governance structures as the key determinant of adaptive capacity and actual adaptation actions is also necessary to address the climate change impacts (UN-Habitat, 2011). This is a particularly important point for the UK's transport governance. The UK's power devolution in 1999 was the borne of the shift in the transport policy and practice at the local level. There are a variety of issues, at different levels of governance, which impede the effective policy implementation in transport sector including lack of joint up thinking across the departments, unclear structure to develop and implement transport policies and a gap between strategic transport objectives and wider government objectives (Akram et al., 2011). The main question is how the UK's transport governance, a system which already is facing with a variety of non-climate issues such as economic, political and institutional challenges, can effectively integrate the climate change adaptation policies into transport-related policies.

Benzie et al. (2011) argue that climate change and its potential impacts are a new kind of problems, hence traditional governing models cannot be used to solve these new problems. Hence, a governance structure that has been established several years ago for addressing a particular issue is not appropriate for addressing climate change. This research examines the extent to which the current transport governance arrangements in the UK are able to address the climate change challenges in an effective manner. Moreover, because of the inherent uncertainty in the climate change projections and the wide knowledge gap about the future impacts of climate change, defining the adaptation objectives, monitoring the process as well as allocating appropriate funding for stakeholders will be more problematic. (Koetse and Rietveld, 2012). Climate resilient cities require "innovative thinking, learning and new governance structure" (Benzie et al., 2011, p.237). Similarly, Martin-Breen and Anderies (2011) argue that the innovation is essential for resilience, and effective governance structures have a pivotal role in promoting innovation.

Scholars from professional backgrounds have mentioned different discourses about the appropriate level of governance for taking action on climate change. Scholars in international law argue that the climate change issue is a global challenge and hence needs a concerted process at the global level to deal with the problem (Arnell et al., 2013, Paavola and Adger, 2006). In contrast, political scientists criticise focusing on the international level and instead emphasise local actors and decentralisation process (Urwin and Jordan, 2008). This reflects that international (and even national) level modes of governance is not sufficiently suited to generate local contextually relevant solutions needed to address the problem (Newig and Fritsch, 2009). Economists argue that taking action at the local level may well be justified, but the implementation of climate change policies at the local level can be constrained if the role that international and national levels can play in the process is not considered (Gupta, 2007a).

Previous studies underline the role of local level actors in climate change adaptation at the local level (Grover, 2013, Wilson, 2006, Manasfi and Greenhalgh, 2011, Dannevig et al., 2012). Although, global action and agreement are required to reduce the greenhouse gas emissions, the most appropriate adaptation to the impacts of climate change can be done by collective actions at municipal and community levels, given the spatially and socially differentiated impacts of climate change and different adaptation options available at the local level, (Tanner et al., 2009, Adger, 2001, Gupta, 2007a). Municipal authorities and local governments can integrate climate change-related policies within the urban development framework by considering greater horizontal and vertical coordination in order to mainstream climate change, offer feasible guidance and develop effective action plans (Bulkeley et al., 2011, ICLEI, 2011, Fünfgeld, 2010, Khailani and Perera, 2013).

Gupta (2007a, p.132) states that "there is no objective way to determine the appropriate level of climate change or other environmental problems, since such problems manifest themselves at a number of levels simultaneously". Hence, research on environmental decision-making needs a framework which considers multiple levels and compares and generalises across the different contexts (Adger et al., 2003). The implication of this suggestion for this research is that it is required to consider a methodological framework which allows us to investigate the process of the climate change adaptation policies at different levels of the governance structure to assess the relationships between actors involved in the process.

Institutional arrangements play a crucial role in the implementation of transport policies (Pemberton, 2000, Akram et al., 2011). According to Legacy et al. (2012), the process of transport planning must involve both the formal and informal organisations and arrangements at different stages of the policy process from design to delivery. It can be concluded that focusing solely on policy makers' and decision makers' viewpoints is not sufficient for effective implementation of climate change adaptation policies or greater integration of climate change adaptation policies with transport policies. It is also required to provide a connection between policy, planning and implementation by making a cross-departmental network and engaging interest group and community level actors in order to make a good governance model.

1.5 Aim and Objectives

By increasing the evidence base about the climate change and its impacts, not only were some international binding targets set to help decrease the emission of the greenhouse gases, but governments also became motivated to plan against climate change. Under the United Nations Framework Convention on Climate Change (UNFCCC), all parties are committed to make progress in adaptation. According to The Kyoto Protocol (Article 4.1-b) all parties, shall

> "formulate, implement, publish and regularly update national and, where appropriate, regional programmes containing measures to mitigate climate change by addressing anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol and measures to facilitate adequate adaptation to climate change" (UNFCCC, 1992).

A climate resilient transport network is a requirement for a modern society (Eichhorst, 2009). An unreliable transportation system can adversely influence economic growth (Crafts and Leunig, 2005, Jaroszweski et al., 2010, Bruinsma et al., 1997, CFIT, 2010). Climate change risk assessments show that the road transport sector is at the risk of climate change (DEFRA, 2012c). However, the main focus of transport researchers has been on the mitigation of greenhouse gas emissions. As discussed further in Chapter 2, although mitigation measures can play a significant role in slowing down the climate change, given the removal of the international political barriers, paying attention to climate change adaptation is necessary. Moreover, according to IPCC (2007a), it is expected that the earth experience the impacts of climate change even if the concentration of CO_2 and other aerosols remains constant today.

Research on climate change adaptation within the transport sector has received little attention (Koetse and Rietveld, 2009). It seems that the earlier studies on the assessment of climate change impacts had not paid enough attention to transport sector. Even the most influential literature such as the Stern Report (Stern, 2007) which covers other vulnerable sectors (e.g. water, agricultural, health and insurance sectors) but not transport. Similarly, the Eddington Transport Study (2006), pays no serious attention to the effects of climate change on transportation. However, research on adaptation is steadily expanding within transport studies (Ahmed et al., 2010) although according to Böcker et al.'s (2012) it still shows an incomplete and fragmented picture of the climate change impacts on the transport sector. Eisenack et al. (2012, p.451) states "although it is frequently claimed that this socially and economically important sector is particularly vulnerable to climate change, there is comparatively little research done on its adaptation". Recently published report by Intergovernmental Panel on Climate Change (IPCC) highlights the need for research on the effects of climate change on transport systems.

"The literature on urban transport and climate change focuses more on mitigation, with less attention to vulnerability, impacts, and adaptation". IPCC (2014a, p.559)

In addition to the risk assessment, Adaptation Sub-Committee (ASC) reports that "capacity building is not yet systematically translating into tangible action on the ground to reduce the UK's vulnerability to climate change" (ASC-CCC, 2010, p.6). Similarly, the level of adaptation activities within the UK's transport sector, have been criticised by scholars. Tompkins et al. (2010, p.631) compared the UK's adaptation activities in different sectors which are vulnerable to climate change impacts (Figure 1-1). They link the lower levels of adaptation activities in 'agriculture and forestry', and 'biodiversity and conservation' sectors to short-term infrastructure investments. However, within this reasoning, they state "we would have expected to see higher levels of [adaptation] activity within the transport sector; however this was not the case".

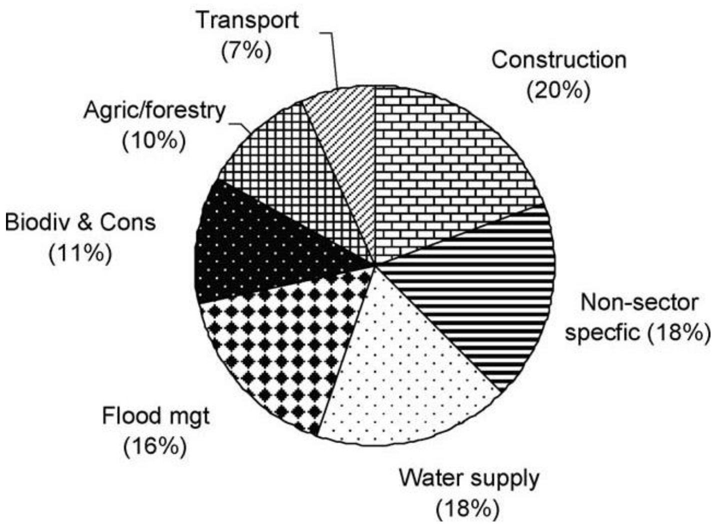


Figure 1-1: Relative levels of adaptation by sector

(Tompkins et al., 2010)

This research pays particular attention to the role of transport governance arrangements in the implementation and delivery of climate change adaptation policies. The existing body of climate change governance literature indicates that many context-dependent factors influence the actual responses of actors in adapting to climate change with these factors including many variables from localised incentives to national level frameworks (Nilsson et al., 2012, Juhola and Westerhoff, 2011). Hence addressing climate change and integrating climate change policies into other policy domains such as transport planning are not straightforward. For example, Langlais (2009) found two different attitudes towards the implementation of climate change related policies at the local level. Some municipalities argue that they are unable to adapt to climate change as they are too small and do not have sufficient resources. However, at the same time, other municipalities claim that they do not have a high level of bureaucracy and thereupon they can respond to impacts of climate change. It can be concluded that the context plays an important role in the development and implementation of climate change adaptation policies.

Meadowcroft (2009) argues that countries with effective governance arrangements have more opportunities to address the impacts of climate change at the local level. Although addressing the climate change through mitigation policies was started about twenty years ago, adaptation to climate change is relatively a recent policy in the UK (see Chapter 2 for more detail). The existing transport governance arrangements in the UK has resulted from the devolution of power and responsibilities to regional/local governments to address the problems of congestion and individual car use primarily through promoting sustainable modes of transport (Akram et al., 2011). The extent to which the UK's existing transport governance arrangements can facilitate the process of climate change adaptation to translate the national adaptation strategies into the local transport policies and actions has received very little attention from researchers (see Walker et al., 2014 for exception). Most of the research about the climate change adaptations are concerned with the climate change risk assessment and very little attention has been paid to adaptation measures and decisions (Arnell, 2010). Focusing on the climate change adaptation in the road transport sector, this study evaluate the effectiveness of the policy making and implementation process aimed at adapting the road transport sector to climate change impacts. The following section describes the aim and objectives of this research.

1.5.1 Aim

The aim of this research is to examine the effectiveness of transport governance arrangements in translating national climate change adaptation policies into the local initiatives and actions.

1.5.2 Objectives

The following objectives have been defined to achieve to the aim of this research:

(1) To review the previous theoretical frameworks developed for analysing policy implementation process with particular emphasis on the applicability of theoretical frameworks in investigating the process of the implementation of climate change adaptation polices.

(2) To investigate climate change adaptation policy frameworks and existing road transport governance arrangements employed by different jurisdictions in the UK.

(3) To develop a methodological framework to investigate the effectiveness of transport governance arrangements in implementation and delivery of the national climate change policies at the local level.

(4) To evaluate stakeholders' views about the transport governance barriers to implement the climate change adaptation policies at the local level.

(5) To analyse and compare the attitudes of stakeholders toward the governance arrangements and the implementation of climate change adaptation policies at the local level.

(6) To draw conclusions and give recommendations to improve the effective integration of the climate change adaptation policies within the road transport governance.

1.6 Research Questions

Considering the research aim and objectives, this study addresses the following research questions:

(i) What are the key issues and developed theories for analysing the policy implementation process?

(ii) What are the differences between 'climate change adaptation frameworks' and transport governance arrangements at different jurisdictions in the UK?

(iii) What factors influence the adoption, implementation and integration of climate change adaptation policies within road transport policies?

(iv) Are there any differences in stakeholders' attitudes toward the factors influencing the process of policy implementation?

(v) What changes in the existing institutional arrangements can improve the integration of the climate change adaptation policies and road transport governance?

1.7 Research Methodology

Deciding the type of design and selection of data collection method mainly depends on the nature of the research questions (Yin, 2009, Frankel and Devers, 2000). Qualitative research approaches are more concerned with the process rather than the outcome. They are appropriate approaches for answering the questions which take the form of "why?" and "how?". Answering some of research questions, such as "What factors influence the implementation and integration of climate change adaptation policies to the road transport sector policy?", needs a wide range of data for the evaluation of stakeholders' views about the barriers in the process of implementing the climate change adaptation policies (see Section 2.6 for different barriers and Section 3.3 for more discussion). On the other hand, quantitative approaches answer questions such as "when", "where" and "how many" and are appropriate when the researchers need to answer the research questions with more detailed descriptions about the issue for example "Are there any differences in stakeholders' attitudes toward the factors influencing the process of policy implementation?" (Neuman, 2007). Hence, considering the research questions presented in Section 1.5, this study employs a mixed design of both qualitative and quantitative methods of data collection and analysis.

Considering the projections of the climate change impacts in the UK and the highlighted factors in the literature regarding the effectiveness of the governance arrangements with particular emphasis on the distribution of powers and responsibilities between stakeholders, two case study areas are selected for further investigation i.e. Belfast and Cambridge. Selection and justification of the case studies have been discussed in Chapter 3. Considering the research questions, aim and objectives, this chapter assesses the methods used in the similar studies and discusses the advantages and limitations of them. It also proposes a methodological framework for analysing the process of the implementation of the climate change adaptation policies in the context of road transport sector. Then a combination of the Neural Network (NN) method and the Monte-Carlo simulation has been used to improve the reliability of Q methodology in extracting and explaining the attitudes of the stakeholders towards the effectiveness of the transport governance arrangements in the implementation of climate change adaptation policies.

1.8 Thesis Structure

Figure 1-2 shows the thesis structure and the methods used to fulfil the five objectives defined in Section 1.5.2. In the theoretical research, the literature review in the context of climate change policy and implementation is conducted. Results of the literature review are presented in Chapter 2. The overall aim of this chapter is to provide an overview about the previous theoretical frameworks utilised by scholars for analysing the process of the policy implementation (objective 1). After doing a brief review of climate change, mitigation, adaptation and resilience (Section 2.2), the focus has been on the policy implementation theories and its applications in practice (Section 2.3 to Section 2.5). Then it is followed by doing the literature review to investigate the barriers to the implementation of climate change adaptation policies (Section 2.6). The outcome of this step is a set of factors surrounding the issues of governance and policy implementation (Section 2.7). These factors are used to evaluate the road transport stakeholders' attitudes towards the effectiveness of governance structures and climate change policy implementation in empirical research. Reviewing the published policy documents, the last part of the Chapter 2, fulfils objective 2. It outlines the current climate change policies and frameworks in UK and devolved administrations (Section 2.8). It then discusses the existing transport governance arrangements across the UK's different jurisdictions in Section 2.9.

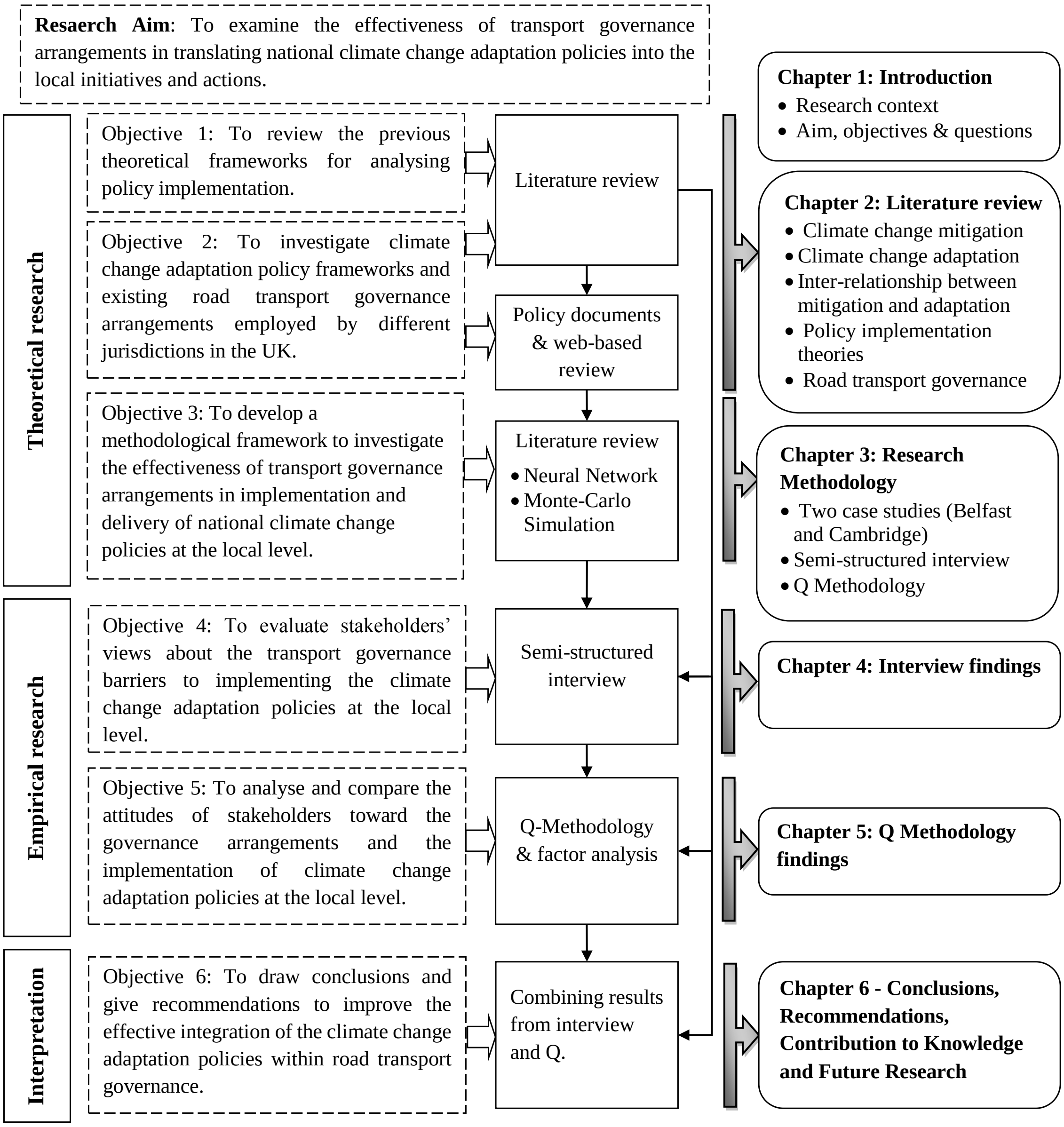


Figure 1-2: Overall structure of thesis, objectives and methodology

The empirical phase of this research employs both qualitative interviews and quantitative Q methodology approaches. In the qualitative part of the research, the focus group discussions and the semi-structured interviews evaluate the road transport stakeholders' attitudes towards the main factors regarding the governance and policy implementation. The qualitative data from in-depth interviews are analysed using a constant comparison and classical content analysis methods. The results, then, are used to generate the concourse (all of the possible statements around the topic) and Q-sample (or Q set: a reasonable number of statements which represent the concourse). The findings of the focus group discussions and semi-structured interviews will be presented in Chapter 4.

In the quantitative part of the research, the Q methodology is employed. Q methodology itself is a mixed method since it comprises both the qualitative sorting of the statements by stakeholders and quantitative analysis of the results using the factor analysis method. The Q method is a systematic method for assessing the subjectivity. In this approach, participants are asked to sort the order of the statements on a bell shape distribution diagram (semi-normal distribution) based on their own perspective. Their sorted responses form the Q-sorting matrix which provides a starting point for data analysis. Data analysis is a four step process: forming the correlation matrix, factor analysis, factor rotation and finally the computation of the factor scores. Using the principle component analysis, Q method produces the eigenvalue of the extracted factors which indicates the significance of those factors (attitudes) among participants. The output of the Q methodology is a set of factors which represents the transport stakeholders' attitudes toward the transport governance, implementation and the delivery of the climate change adaptation policies at the local level. The findings from the Q method used in two case study areas are reflected in Chapter 5.

In Chapter 6, the results of qualitative (focus group discussion and interviews) and quantitative (Q Methodology) data are combined to make the conclusion of this research. The comparison of the results obtained from two case study areas utilising different transport governance structure has provided a valuable insight into the main factors where these factors influence the effectiveness of the transport governance arrangements in the process of climate change adaptation at the local level. Figure 1-2 shows the overall structure of the thesis including the objectives and the methods used to address those objectives.

Chapter 2 - Implementation of Climate Change Adaptation Policies

2.1 Introduction

More than 50% of the world population live in urban areas, and this figure is increasing every year (Hallegatte and Corfee-Morlot, 2011, p.4). It is estimated that by 2050 67% of the world population will live in urban areas. In developed countries this figure is around 86% (Jaroszweski et al., 2014). Climate change will affect both transportation infrastructures such as roads, tunnels, railways and port facilities, and the transport service for example by indirect costs of delays and trip cancellation (IPCC, 2014a, Hallegatte and Corfee-Morlot, 2011, Chinowsky et al., 2013). According to Carrillo and Chinowsky (2013) roughly half of the road maintenance cost is due to weather stresses. Greater contribution of cities to the economy, due to the concentration of resources and infrastructure, necessitates that urban decision makers should develop appropriate climate change policies, both mitigation and adaptation. They should also remove the existing barriers against the effective implementation of the climate change adaptation policies (Khan and Munawar, 2011, Walker et al., 2014).

The focus of this chapter is on the policy implementation theories in relation to the climate change adaptation in order to discover the advantages and limitations of different theories and models which have been used in previous studies in order to evaluate the policy development and implementation process. Figure 2.1 shows the outline of this chapter. Section 2.2 discusses background information pertained to this study which involves the concepts of climate change mitigation, adaptation and resilience. It also provides a brief history of the climate change adaptation at global and UK level from the establishment of the Intergovernmental Panel on Climate Change (IPCC) up to now.

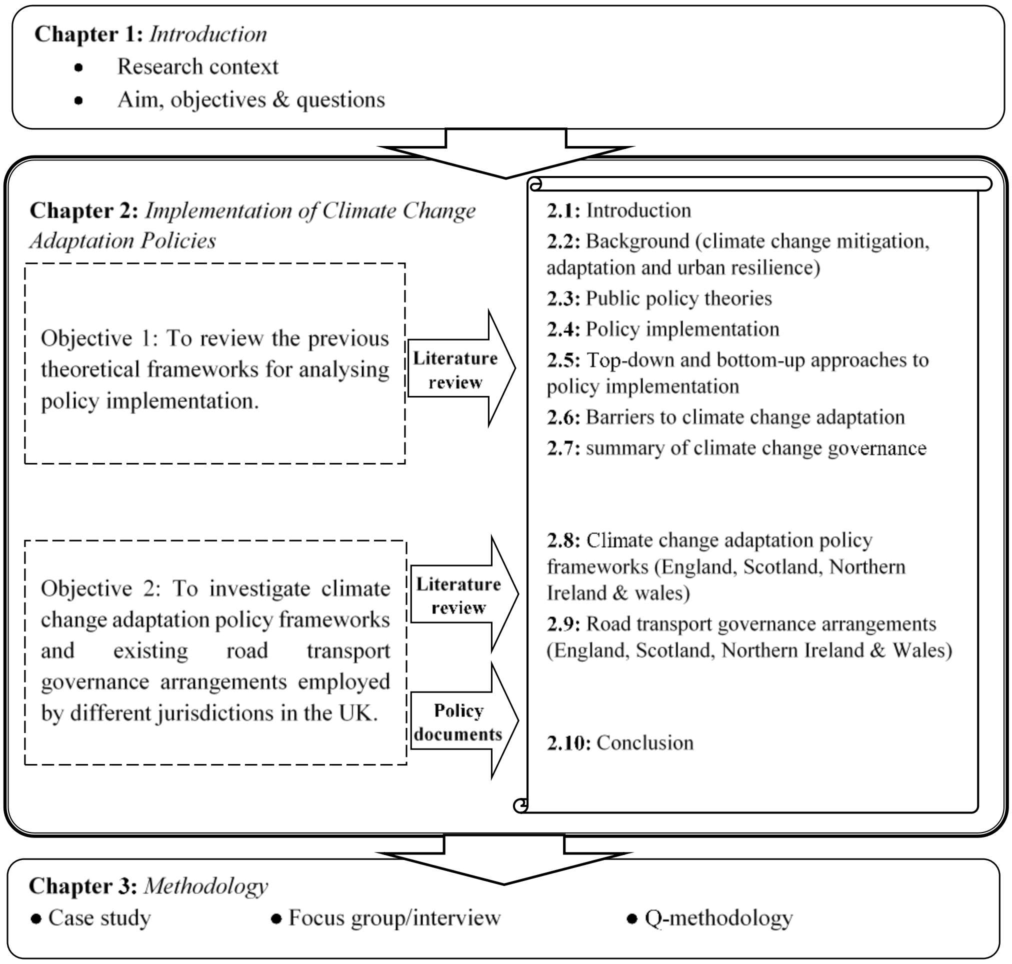


Figure 2-1: Structure of Chapter Two

Section 2.3 explains three theoretical frameworks and models developed for the purpose of policy analysis to further understand the process of decision making and the factors influencing this process. It also provides a brief background on the theories of policy implementation. The concept of the policy implementation is discussed in Section 2.4. In Section 2.5, the top-down and bottom-up approaches for the policy implementation are discussed. The most important theories and models for each perspective are presented. Criticisms for each of these perspectives are stated and advantages and limitations of them are explained.

Drawing upon the recently published literature, Section 2.6 looks at the key obstacles against the implementation of adaptation policies at city levels. These barriers have been categorised in five thematic groups, namely scientific, institutional, economic, political and finally social factors. Summarising the findings of the previous sections, Section 2.7 discusses the main themes surrounding the climate change governance to fulfil the Objective 1 of the research.

The current devolution of the transport powers between different actors dates back to 1998. In response to the traffic growth, pollution and decline in bus and rail service, the British government issued a White Paper in 1998, "A new deal for transport: better for everyone", in order to enhance the sustainability in transport sector (DETR, 1998). This white paper identified the need for introducing sustainable and environmentally friendly forms of transport such as public transport, walking and cycling. The white paper also identified the need for defining the future direction and policy agenda of national government with respect to the transport system. Objective 2 is addressed through the literature review and reviewing the policy documents and web sites of transport organisations. Discussing the devolution of transport powers and responsibilities, Section 2.8 assesses the policies which are currently in place in support of the climate change adaptation in the UK's different jurisdictions (England, Scotland, Northern Ireland and Wales). Section 2.9 reviews the road transport governance arrangements in the UK's different jurisdictions. To do so, the distribution of powers and responsibilities among the road transport stakeholders in terms of decision making and implementation of the policies is discussed. Finally, a summary of this chapter is presented in Section 2.10.

2.2 Background to Climate Change

2.2.1 Climate Change Mitigation and Adaptation

The Earth is becoming warmer mainly because of the increasing amount of heat-trapping gases known as greenhouse gases (GHGs), in particular carbon dioxide and methane (IPCC, 2007b, Crowley, 2000, Karoly, 2014). According to IPCC's projections, in the next two decades the earth will become warmer by about 0.2°C per decade as a result of the greenhouse gas emissions (IPCC, 2007b). The IPCC's latest report also shows that there is a 95% certainty that human influence is the dominant cause of the observed climate change (IPCC, 2013). This report reveals that the efforts in the past did not successfully decrease the effects of climate change. The report predicts an average temperature increase of 2.6–4.8 degrees Celsius (°C) for the Earth by the end of this century if the current rise in the emission rates continues. It should be emphasised that still some researchers denies the anthropogenic climate change as they assume that the climate change is a natural change (not caused by CO_2) (Anderegg et al., 2010). However, according to Anderegg et al. (2010), 97-98% of the most active researchers in the field of climate change have supported the tenets of anthropogenic climate change.

The concern about climate change and its potential impacts is increasing year by year. According to Lockwood (2011) the dominant view is that climate change is the biggest challenge in the 21st century. This does not mean that today's crises such as energy security, food shortage or ecological degradation are less important, rather this means that climate change potentially can exacerbate existing crises (Harry and Morad, 2013). For example, low-income urban householders who don't have sufficient financial or technical resources are mainly situated in more vulnerable areas. Extreme weather conditions can affect them by heightening the exposure to health risks and preventing access to health centres as a result of damaged critical public transit links (IPCC, 2014a). Hence, the potential impacts of climate change will have resonance with the other social and economic problems (UNESCAP, 2012).

As discussed in Chapter 1 and will discuss in Section 2.2.3, initially, it was supposed that the mitigation measures and reduction of greenhouse gases can address the climate change issue. Hence, governments in both developed and developing countries, initiated policies to promote the reduction of energy consumption and GHG emissions (Kern and Alber, 2008, Bulkeley et al., 2011). Reducing the energy consumption and potential savings from it were the main incentives for organisations to involve themselves in the mitigation activities. Governments also developed new certificate schemes to motivate organisations to recognise their performance in reducing carbon emissions such as Carbon Trust Standard in the UK (2001) and Energy Star in the USA (Bulkeley, 2009, Thomas et al., 2011, Sperling and Cannon, 2010). Chapman (2007) reviews the role of transport in contributing to climate change and proposed some methods by which this sector can reduce its consumption of fossil fuels and consequently can reduce the greenhouse emissions. In recent years, the research about the climate change mitigation in transport sector is linked to other benefits for the population in order to provide more evidences for the need for sustainable modes of transport. For example, Shaw et al. (2014) review the evidences from transport policies and their impacts on health.

Since, in the UK, the transport sector was a significant contributor to GHG emissions, it came more to the forefront of the government's agenda. The UK government published a White Paper, "*A new deal for transport, better for everyone*", in 1998 in order to initiate sustainable and environmentally-friendly modes of transport to enable the UK to tackle climate change by reducing greenhouse emissions (DETR, 1998). One of the key elements of this White Paper was that the government would no longer use the strategy of "predict and provide" which accommodates the traffic growth by increasing the capacity of the road infrastructures (Noland and Lem, 2002, DETR, 1998). The integration of different modes of transportation and enabling alternative options (such as public transport and non-motorised modes) were seen as the key goals of a sustainable transport system (Goodwin, 1999). In addition a new appraisal method comprising five objectives (environment, safety, economy, accessibility and integration) was introduced for road schemes. According to Nellthorp and Mackie (2000) and Noland and Lem (2002), almost all of the environmental factors were influential in the new appraisal method.

In 2001, IPCC published the Third Assessment Report (IPCC, 2001) emphasising that the mitigation policies and measures are not solely sufficient to tackle climate change since the emission of greenhouse gases prior to these mitigation measures, and also presence of a number of international political barriers for the reduction of greenhouse gas emissions can impact the nature and the built environment in the long-term. IPCC's next reports further highlight this challenge (IPCC, 2007a, IPCC, 2014a). According to IPCC (2007b) and Stern (2007), it is not possible to avoid the impacts of climate change in the coming decades.

In recent years, there has been a general agreement amongst researchers that along with the reduction of greenhouse gases emission, adaptation to the climate change impacts is also necessary. Climate change adaptation is about "managing the unavoidable" regardless of immediate emission control efforts (Wilson and Piper, 2010, p.19, Gillett et al., 2011). IPCC (2007a, p. 6) has defined climate change adaptation as "the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities". This study will use Nelson et al.'s (2007, p.397) definition for climate change adaptation which is the decision-making process and the set of actions undertaken to maintain the capacity to deal with future change. As discussed briefly in Chapter 1, and will be discussed further in Section 2.6, the process of the climate change adaptation and its integration into the transport policies are a complex political process involving multiple stakeholders at different levels of the governance structure. Employing Nelson's definition of climate change adaptation provides us with a simple and accurate description of this complex process.

Pielke Jr (1998, p.166) has predicted four climate change adaptation reasons, each of which remains relevant:

1- There are political and technical barriers in the way of mitigation in both developed and developing countries.
2- Although there is uncertainty inherent in climate change research, but some degree of climate change is inevitable.
3- Beside human-induced factors, there are many other factors which contribute to climate change.
4- Population growth and technological change will increase the vulnerability of the society to climate change impacts.

According to Tompkins et al. (2010) climate change adaptation involves both building adaptive capacity (increasing the capacity of organisations or groups to adapt to changes) and implementing adaptive decisions in order to transform that capacity into action. Climate change has a close relationship with sustainable development (Smit and Pilifosova, 2003). There are already several synergies between these two broad concepts such as renewable energy, energy efficiency and sustainable land-use planning (Beg et al., 2002). For example, highlighting the role of the climate change policies in sustainable development, Greaker et al. (2013) propose an approach to integrate the sustainable development into climate change indicators. On the one hand, climate change is due to unsustainable development, on the other hand sustainability can increase the resilience of the systems to climate change and helps them to adapt to its impacts by means of good institutional arrangements and governance structures, adequate infrastructure, and enhancement of other economic related factors (Adger et al., 2005, IPCC, 2014a, chapter 10). Harry and Morad (2013) point out that the climate change policies can be seen as pivotal to sustainable development. Huq et al. (2008, p.52) summarise this relationship as follows:

> "Good (or sustainable) development (policies and practice) can (and often does) lead to building adaptive capacity. Doing adaptation to climate change often also means doing good (or sustainable) development."

Despite acknowledging the importance of adaptation, the climate change policies are dominated by the mitigation measures (Mimura, 2013). However, studying how to implement appropriate adaptation measures is a growing area of interest for researchers (Larsen et al., 2012), although it is still in its infancy (Carlsson-Kanyama et al., 2013). In some cases urban policies address the climate change adaptation. But there is still a tendency to focus mainly on mitigation, and "action on climate adaptation has remained marginal and [is] usually a secondary impact of policies designed to tackle other urban problems" (Bulkeley et al., 2011, p.152, Antonio and Oliveira, 2009).

Integrating the climate change mitigation and adaptation policies has been suggested as a beneficial strategy (Klein et al., 2005). Not every mitigation initiative can be coordinated with adaptation policies; however, there are many opportunities to make them work together (Antonio and Oliveira, 2009). For example Lobell et al. (2013) have shown that in the agriculture sector the adaptation measures can have positive consequences for the mitigation due to avoided emissions from land use changes. As an example in transport sector, increasing green spaces and street trees in urban areas can help the road transport system to adapt to extreme weather events and flooding (adaptation). In addition, it can mitigate the greenhouse emissions (mitigation) by providing more shading and cooling and consequently reducing the need for air conditioning (Inturri and Ignaccolo, 2011). It is important to emphasise that adaptation may have costs as well, for example although using air conditioning in cars is an adaptation measure against heat waves, but increasing the demand for air conditioning can increase the fossil fuel consumption (Adger et al., 2005). Eriksen et al. (2011) highlight the significance of the sustainable adaptation and propose the principles of sustainability in the context of the climate change adaptation. These principles recognise the context for vulnerability, acknowledge the different values and interests, integrate local knowledge into the adaptation plans, and finally consider the feedbacks between local and global processes.

Table 2-1 shows the characteristics of the mitigation and adaptation responses in addressing the climate change issues. According to this table, it is obvious that the mitigation and adaptation strategies have different characteristics in terms of the decision making and implementation processes. Most importantly, this table highlights the main barriers which policy developers and analysts can encounter when integrating the climate change adaptation policies into other policy domains. As discussed in section 2.6, the cost of the adaptation, uncertainty of the climate change, long-term nature of the implications of the adaptation measures and their resonance with other political-economic issues are the main barriers for the successful implementation of the climate change adaptation policies. However, the adaptation measures have some advantages over the mitigation activities. The most important motivation for the local decision makers to adapt to the impacts of the climate change can be its local effect. Despite the mitigation measures which have global effects, most of the adaptation measures and policies can benefit the local/regional areas. In addition, climate change adaptation measures offer a shorter time frame to be developed and implemented. Knowing that most action in climate change and transport context are focused on the mitigation (see Chapter 1), it seems that the overall motivations and constraints of climate change adaptation cannot convince the transport decision makers to adapt this sector to the impacts of the climate change. It can be concluded that in order to assess the implementation of climate change adaptation policies, the focus only on the characteristics of the policy would not give the full picture of the process. In Section 2-3 and Section 2-4, the most influential theories of the policy implementation have been discussed. It will be shown that in addition to the constraints/motivations of the climate change adaptation (as described in Table 2-1), there are many other factors which can hamper or facilitate the process of climate change adaptation.

Table 2-1: Characteristics of mitigation and adaptation

Characteristics	Mitigation	Adaptation
Benefited systems	All systems	Selected systems
Scale of effect	Global	Local to regional
Life time	Centuries	Years to centuries
Lead time	Decades	Immediate to decades
Effectiveness	Certain	Generally less certain
Ancillary benefits	Sometimes	Mostly
Polluter pays	Typically yes	Not necessarily
Payer benefits	Only little	Almost fully
Monitoring	Relatively easy	More difficult

Source: (Füssel and Klein, 2006)

2.2.2 Climate Change Adaptation and Urban Resilience

In an influential article, Holling (1973) coined resilience as a measure of the ability of the systems to absorb disturbances and still retain their basic function and structure. Hence, a higher degree of resilience indicates lower vulnerability and vice versa (Müller, 2011). In the context of climate change, Jerneck and Olsson (2008, p.174) understand resilience as "a common concept related to vulnerability and adaptation". Isoard (2011, p.53) outlines the aim of adaptation as "increasing the resilience of natural and human systems to current and future impacts of climate change". Abdul Kader et al. (2012) consider resilience as the objective of the climate change adaptation. Similarly, many other scholars have related resilience to adaptation and sustainability (Xu and Grumbine, 2014, Jaroszweski et al., 2014, Wu and Wu, 2013). The use of the term "resilience" has been frequently used with climate change and its impacts having a strong influence on the popularization of this catchword (Müller, 2011).

IPCC defines resilience as:

> "the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions" (IPCC, 2012, p. 5).

> "The capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation." (IPCC, 2014a, p.5)

As discussed in Section 2.1, urban areas play a crucial role in the ongoing climate change debates. According to Lang (2011), urban resilience research considers climate change and its impacts as well as the responses of urban areas to other potential shocks that may occur such as terrorism and earthquake. Prasad et al. (2009) have defined a resilient city as one that is able to sustain itself when shocked or damaged. Mortime (2010) and Gordon (2011) define urban resilience as the ability to cope with short term disruption and (or) adapt to large scale change with a minimum loss of function. Furthermore, Henstra (2012, p.178) defines a climate-resilient city as "one that has the capacity to withstand climate change stresses, to respond effectively to climate-related hazards, and to recover quickly from residual negative impacts". What all these definitions have in common is that the ability of an urban area and its infrastructures to adapt to the climate change impacts is an important attribute for building a resilient city.

After more than thirty years of debate about resilience, and despite the existence of many definitions, there is still a lack of awareness about the factors that make some urban areas resilient and others vulnerable (Müller, 2011, Klein et al., 2003). However, Heinrichs and Krellenberg (2011) argue that, in simple terms, climate resilience is the opposite of vulnerability. Shaw and Theobald (2011, p.9) state that "resilience is centrally concerned with developing holistic approaches to the management of risk". Hence, factors such as sensitivity and exposition to climate hazard that increase the vulnerability of system to the climate change impacts will decrease the resilience of the system to those hazards. In contrast, adaptive capacity enhances resilience and decreases the vulnerability of the system against the climate change impacts.

Although cities have been determined as the risk potential hotspots within the climate change literature (Prasad et al., 2009, Birkmann et al., 2010), as discussed in Chapter 1, but it is increasingly hoped that improved urban governance can enhance the adaptive capacity and decrease the vulnerability of an urban system to climate change (Heinrichs and Krellenberg, 2011, Bulkeley et al., 2011, Bulkeley, 2009, Tanner et al., 2009). Referring to the "resilience of what", Resalliance (2007) identified metabolic flows, governance networks, social dynamics and the built environment as four main themes that have pivotal role in the resilience of an urban system.

Bahadur et al. (2010) argue that high diversity, effective governance, acceptance of uncertainty, community involvement and the inclusion of local knowledge are the most important indicators for measuring the level of resiliency for a city. Tanner et al. (2009) identified five characteristics for a resilient urban governance model i.e. decentralisation and autonomy, accountability and transparency, responsiveness and flexibility, participation and inclusion, and experience and support. In fact, good governance can improve adaptation responses by introducing the proper policies and improving the collaboration between different stakeholders (Breen and Anderies, 2011).

Urban areas represent a very important geographical scale in the climate change debates, not only because of their role in emitting greenhouse gases and their vulnerability to the climate change impacts, but also the link between the sustainable development and climate change policies in these areas can play a catalyst role in developing innovations for both mitigation and adaptation (Kern and Alber, 2008). Cities in the UK have begun to adapt to climate change and have made significant progress over the last few years; however according to the Adaptation Sub-Committee's report (ASC-CCC, 2012), the current "build and protect" approach increases the cost of protection in the face of climate change. Efforts to mainstream climate considerations (integrating climate change concerns within existing processes) are making progress, but transformation (for example IPCC's High++ emissions scenarios; +4°C) requires city authorities to re-think about the potential impacts of climate change on urban transportation systems and their infrastructures. According to Benzie et al. (2011) although some cities such as London and Manchester have started to adapt to climate change, their ability to meet the transformation challenge is not clear yet.

2.2.3 Climate Change Adaptation in UK

Gupta (2010) cites the first World Climate Conference in 1979 as the first event where climate change was discussed at a global level. The Intergovernmental Panel on Climate Change (IPCC) was established in 1989 and the First Assessment Report (FAR) was published in 1990 after the Second World Climate Conference (SWCC) held by the World Meteorological Organization (WMO). Gupta calls this period (1979-1990) as the initial steps in "framing the problem" of the climate change issue. IPCC (1990) predicted an increase in global mean surface air temperature for the next decades (1990-2100) and suggested that the reduction of GHG emissions is essential to avoid the future climate change impacts. In this period although specific messages regarding the importance of climate change problems were disseminated at various conferences and meetings, there was no any binding target or responsibility for the mitigation. On the issue of adaptation, FAR (IPCC, 1990) offered some recommendations such as public education and information, technology development and transfer and changing the economic mechanism at the international level (IPCC, 1990).

By increasing the evidence base about the climate change and its impacts, not only were some international binding targets set to help decrease the emission of the greenhouse gases, but governments also became motivated to plan against climate change. Under the UNFCCC (United Nations Framework Convention on Climate Change), all parties are committed to make progress in adaptation. According to Article 4.1(b) all parties, shall

> "formulate, implement, publish and regularly update national and, where appropriate, regional programmes containing measures to mitigate climate change by addressing anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol and measures to facilitate adequate adaptation to climate change" (UNFCCC, 1992).

In the UK, adaptation to climate change impacts can be divided into three distinct phases (Boyd et al., 2011). The first phase was between the establishment of the IPCC in 1989 and the first assessment of the impacts of the climate change by 1996. In This phase the main emphasis of both academics and politicians was to decrease GHG emissions (Boyd et al., 2011). The outcomes of the government efforts on adaptation was the establishment of the Climate Change Impacts Review Group (CCIRG) by the Department of the Environment, Transport and Regions (DETR). In addition, two reports were produced about the potential impacts of the climate change in UK (CCIRG, 1991, CCIRG, 1996). The CCIRG91 and CCIRG96 tools were launched after FAR (IPCC, 1990) and SAR (IPCC, 1996), respectively. Although impacts of climate change was assessed in this phase, there was limited emphasis on adaptation. In other words, climate change impact assessment was used as an awareness raising method for mitigation (Boyd et al., 2011). According to West and Gawith (2005) and Boyd et al. (2011), although, at the time, this phase and its outcomes (CCIRG, 1991, CCIRG, 1996) were ground-breaking in assessing the climate change impacts, but there were some limitations for example the published risk assessments were not integrated across the sectors, and also the stakeholders had not been engaged in the risk assessment processes, as a result, the reports could not provide helpful information for stakeholders to respond to climate change. Furthermore, these risk assessments were not able to make a complete picture of the UK impacts since they were based on different scales, different data and different assumptions.

The second phase of adaptation (1997-2007) can be named as 'Encouragement of adaptation policy and practice' period for adaptation (Boyd et al., 2011). Under devolution in the United Kingdom in 1998, the responsibility to climate change adaptation was devolved to the national authorities in Scotland, Northern Ireland and wales as discussed in Section 2.8. The Climate Change Programme 2000, published by DETR, Scottish Executive, The National Assembly for Wales and Department of the Environment in Northern Ireland, can be considered as the first output of the second phase of adaptation in the UK (Boyd et al., 2011). In this phase, the focus of the UK government and devolved administrations was still on mitigation. Such an attitude can be seen clearly in the documents. "The worst effects of climate change can be avoided if the world begins now to cut its emissions of the greenhouse gases that cause climate change." (DETR, 2000, p.4). The Climate Change Programme 2000 (Scotland) directly mentioned the importance of mitigation in the first line of its adaptation chapter; "the focus of this Programme is on the Scottish Executive's efforts to reduce greenhouse gas emissions…" (Scottish-Executive, 2000, p.44). However, there were some signs showing that the government had been motivated to start the process of adaptation to climate change mainly through engaging the stakeholders.

In transport sector, Department for Transport (DFT) published 'The Future of Transport: a network for 2030' in 2004. Although this plan had predicted many measures for climate change mitigation (for example by linking the public transport, cycling and clean motor vehicles to GHG emission reduction), there was no significant warning signals about concerns regarding potential impacts of climate change on the transportation system. Only one paragraph was allocated to climate change adaptation. It outlines that this sector is at the risk of flooding during winter and extreme heat waves in summer (DFT, 2004).

The third phase of climate change adaptation started with the adoption of the Climate Change Act (2008). As discussed in Section 2.8, in this phase, both climate change mitigation and adaptation gained equal importance. Together with the Netherlands and Germany, the UK is now taking the lead on the climate change adaptation (Biesbroek et al., 2010). Both climate and non-climate triggers and drivers, directly and indirectly, have had an important influence in development and implementation of the UK's climate change adaptation strategy (Tompkins et al., 2009). According to Biesbroek et al. (2010), Ladrech (2011) and Le Quesne et al. (2010) climate change impacts (especially extreme weather events), the UNFCCC and EU policies, economic cost of inaction, scientific research, NGO advocacy, private sector interests and media were the key drivers for initiation of national adaptation policies.

2.3 Simplifying Complexity: Public Policy Theories

As discussed in Chapter 1, the formulation and implementation of the climate change adaptation policies is a complex process. Sabatier (1999, p.4) states that:

"*given the staggering complexity of the policy process, the analyst must find some way of simplifying the situation in order to have any chance of understanding it*". Hence a review of the theories about the public policy process can be beneficial in better understanding of this complex process. This section explains three theoretical decision making frameworks and models in policy analysis; the stages heuristic framework, institutional rational choice model and incremental model. There are other analytical approaches for policy analysis. However, these three models have been selected as the entry point to the theories of decision making to provide the background information about the theories of policy implementation. In the next sections (Section 2.4 and Section 2.5), the most prominent theories of the policy implementation have been discussed in more detail.

2.3.1 The Stages Heuristic Framework

The Stages Heuristic Framework (SHF) divides the process of public policy into four broad stages: agenda setting, policy formulation, policy implementation and policy evaluation (Walt et al., 2008). In some literature, dissemination has also been included in this framework to build a five-step framework (Corfee-Morlot et al., 2009). This approach seeks for factors (motivations and drivers, obstacles and other requirements) affecting the process within each stage (Sabatier, 2007). In this framework, the policy process starts with identifying the problem and passes through a number of successive stages. One of the main assumptions of this framework is that the policy process continues on a stage to stage basis. As a result, SHF suggests that the reason for the failure of a policy can be found in one of the stages of the policy process (Hill and Hupe, 2002).

The stages heuristic framework (policy cycle) is one of the best known frameworks for analysing the process of climate change adaptation policy (ATE, 2005, Corfee-Morlot et al., 2009, Moser and Ekstrom, 2010). Corfee-Morlot et al. (2009) argue that although sub-national governments have released different climate change action plans, but the development and implementation of different local and regional climate change action plans often follow a common policy-making continuum that can be explained by the Stages Heuristic framework.

This framework has a practical orientation dividing the complex process of public policy into discrete stages. Some scholars criticise this approach for the following reasons (Jenkins-Smith and Sabatier, 2003, Sabatier, 2007):

1. It neglects a set of drivers that influence the policy process within and across the stages, thus in practice it is not a causal theory.
2. The proposed sequence of the stages in the policy process is often descriptively inaccurate.
3. This framework never takes into account the relationship between policy implementation and evaluation, and thus has a top-down bias.
4. This framework oversimplifies the complex process of policy cycle. For example policy evaluation often involves multiple and interacting cycles.

2.3.2 Institutional Rational Choice Theory

The rational choice theory involves a variety of methods used to predict the behaviour of individuals in the context of different economic and political situations. Supporters of this theoretical framework argue that individuals are self-interested/egoistic and the rational individuals within the policy network aim to improve their own circumstances and maximise their utilities by changing institutional arrangements, subject to one or more constraints and based on their own perception of benefits and costs (Schlager and Blomquist, 1996, Berman and Kofinas, 2004, Ostrom, 2007).

A rational model requires resources, criteria for choosing between different options, the ability to process information and sufficient knowledge to evaluate the outcomes. In this framework actors operate within the existing rules, but they may also be able to change them and establish a new rule set in a way that makes their preferred outcomes more likely (Schlager and Blomquist, 1996). According to Green (2002), this model has been modified in a number of ways to have more flexibility in describing real phenomena. Some of the modified models are the dynamic model (or intertemporal model) which allows the decision makers to plan for the future; the uncertainty model which is appropriate when the target is not known with certainty; the incomplete information model and the strategic behaviour model (or game theory) which is suitable when there are a fewer number of actors involved in decision making.

In practice, this model analyses the policy process in six steps (Green, 2002):

1) Identifying actors and making assumptions about their objectives, goals or values.
2) Identifying the constraints which each actor faces,
3) Determining the decision rules,
4) Characterising the equilibrium of the model based on the objectives, constraints and decision rules,
5) Exploring new optimal point(s) for the equilibrium of the model, and
6) Choosing the best alternative.

Although the rational choice model has never been abandoned, but it has been widely criticised for its theoretical assumptions and specially for difficulty in meeting the “formidable requirements” (Camhis, 1979, p.35, Blau, 1997, Hodgson, 2012). In this regard, the decision makers often do not have all the required information to examine all relevant consequences of the various alternatives. For example in the climate change context, the severity and frequency of different impacts have remained uncertain. Beside forecasting errors, transport planners also intentionally misrepresent costs, benefits and risks in order to increase the likelihood of their own projects to gain approval and funding (Flyvbjerg, 2007, Flyvbjerg et al., 2002, Cantarelli et al., 2012). Furthermore, because of its emphasis on the individual decision-making, the rational choice model has been criticised regarding the primary unit of analysis. Opponents argue that the values and objectives of an individual cannot represent the values and objectives of an organisation (Green, 2002). Another stream of critics argue that people do not behave in rational ways, Barrow (2006, p.274) states "they can expend huge resources on something of little value to their survival and welfare or benefit to the environment, and then haggle and fight to avoid spending far less in tax to achieve real benefits". For example, although the cost of adapting to climate change for large infrastructure projects such as transport infrastructures is usually less than 1 percent of baseline costs (Hughes et al., 2010), but as discussed in Chapter 1, climate change adaptation in the transport sector has not received significant attention.

The literature shows that the social network between formal and informal institutions can play an important role in adapting a system to climate change (Juhola and Westerhoff, 2011). As a result, the focus on the formal decision makers, suggested by the rational choice model, cannot provide us with a realistic picture about the process of the climate change adaptation. Moreover, traditionally, the planning and implementation of climate change adaptation policies at the city level are the responsibility of the environment department (Corfee-Morlot et al., 2009). Consequently, the values and interests of an individual from the environment department cannot equate to the values and interests of the transport department, as one seeks to maximise his/her values which is (for example) prevention of air pollution, while the latter (the transport department) wants to have a minimum traffic level.

This framework has also been criticised because of its assumption about the stable preference of individuals. Opponents argue that many external factors can change individuals' viewpoints. According to Adger et al. (2009), adaptations are used to adjust the system to changes and respond to the perceived risks and hazards. Leiserowitz (2004) has showed that climate change risk perception and policy priorities can be changed by mass media. Indeed, critics indicate that the complete rationality cannot be assumed in policy making. To summarise, although this approach can provide opportunities for the novel confirmation of theories because of its mathematical nature, (Green, 2002), as discussed in Section 2.6.1, there are many scientific and institutional barriers in the process of climate change adaptation which can hamper the effectiveness of the rational choice theory in analysing the adaptation of the transport sector to the impacts of climate change.

2.3.3 Incremental Model

Lindblom (1959) highlighted the importance of 'non-rational' aspects of the policy process such as power, social interaction and the connections between different stages of the policy cycle. Challenging the "scientific" assumptions of the rational model, Lindblom proposed an approach known as the incremental model. This model supposes that only a limited number of alternatives, differing marginally from the existing policies and government activities, are available (Gregory, 1989). Lindblom (1959) argued that the rational decision making model is not invalid, however in practice the process of decision making is about the complex policy questions that are derived by the method of "successive limited comparison".

According to Lindblom's approach, the planned goal realisation not only is impossible but also it is not desirable in decision making because in some circumstances policy makers try to avoid problematic situations rather than achieving the goal. In addition, choosing a rationally selected option can be ignored due to the lack of consensus between different individuals. In the incremental model, the decision makers have only a few number of familiar policy options which usually have marginal changes from existing policy rules (Rajagopalan and

Rasheed, 1995, Gregory, 1989). Hence, participation of different stakeholders involved in the decision making process and the negotiation between them play an important role in the policy choices. In this model, a good decision is the one that decision makers can agree upon through conflict minimisation, not the one that is more appropriate for an agreed objective (Rajagopalan and Rasheed, 1995).

According to Parsons (1995), incrementalists are concerned with the concepts of power and politics. Emphasis on the negotiation in Lindblom's model highlighted the role of power in the process of decision making. Policy making requires bargaining and negotiation which occurs step by step, incremental and through trial and error (Gregory, 1989). Hence, actors involved in the decision making process, with different degrees of power, will have different portions of bringing about the change in policies.

One of the main disadvantages of the incremental model is related to its relevance to changing nature of existing policy. Based on this, an incremental model is only appropriate when decision makers want to change the existing policy which is not the case in studying climate change adaptation policies as the climate change adaptation is a relatively new field for policy development particularly at the local level. In addition, this model has been criticised for its assumption about the gradual change in the policy (incremental change). According to Bierbaum et al. (2013) and Fidelman et al. (2013) in certain cases, transformative (not incremental) changes and actions may be needed to adapt to significant impacts of the climate change. Hence, this model is not applicable for making "large" or "fundamental" decisions and policies as these fundamental policies can set the context for numerous incremental ones (Etzioni, 1967).

2.4 Policy Implementation

Policy Implementation as an interdisciplinary research area can be found at the intersection of public administration, public management, organizational theory and political science studies (Schofield and Sausman, 2004). Health, education, law, environment, energy, agriculture and economics are the main fields studied within this research stream (Saetren, 2005). Parsons (1995) argues early studies of public policy were focused on the resources needed to achieve the predefined goals. To do so, inputs and outputs were the main focus of researchers. As a result, the researchers did not make much effort to analyse the process of policy implementation. Meter and Horn (1975) have four reasons for this. Firstly, implementation was understood to be simple by researchers. Secondly, the focus of scholars was mainly on the policy making, and the growth of 'Planning, Programming & Budgeting' approach encouraged policy analysts to neglect the policy implementation problems. Thirdly, it was difficult to find relevant actors and required factors to complete the implementation study. And finally, the existence of the extended time period and multiple actions simultaneously in the implementation process made it difficult for researchers to analyse the process.

Implementation literally means carrying out, producing or completing a given task, and the process of policy implementation involves a number of actors and organisations such as politicians, civil servants and those working on social policy issues in the statutory, business or voluntary sectors (Hill and Hupe, 2002). Pressman and Wildavsky defined policy implementation as "a process of interaction between the setting of goals and actions geared to achieve them" (Paudel, 2009, p.36-7). Meter and Horn (1975, p.447) provided a more specific definition; "policy implementation encompasses those actions by public and private individuals (or groups) that are directed at the achievement of objectives set forth in prior policy decisions". Some scholars have even wider perspective. O'Toole (2000, p.266) outlined policy implementation as "what develops between the establishment of an apparent intention on the part of government to do something, or stop doing something, and ultimate impact in the world of action".

For Hjern (1982, p.303), "implementation is the carrying out of a basic policy decision, usually made in a statute" and implementation analysis is the act of identifying the factors that affect the compliance or deviance of the implementation outcome from the policy objective. Hence, unlike the impact studies that usually ask "what happened?", implementation studies ask "why did it happen?" (Brynard, 2005). As discussed further in Chapter 3 (methodology), these characteristics of implementation studies have significant implications in designing methodological framework for the empirical investigation of climate change adaptation process in road transport sector. The following sections discusses the most important approaches of the policy implementation. In Section 2.3, three theoretical frameworks for studying the public policy were discussed. Section 2.5 provides more specific theoretical frameworks which have been used for analysing the policy implementation.

2.5 Approaches to Policy Implementation

The evolution of policy implementation research led to a major confrontation between two perspectives (known as 'top-down' and 'bottom-up'), which have become two 'schools of thought' for studying and describing the implementation (Paudel, 2009, Hill and Hupe, 2002, Matland, 1995, Sabatier, 1986). Until the 1980s, the debates between scientists about policy implementation were based around which approach (top-down or bottom-up) is more suitable to explain the outcomes of public policies. In the following section (Section 2.5) these two approaches for policy implementation are reviewed. Criticisms of each perspective are presented and their advantages and limitations are discussed. In Section 2.6, the main barriers of climate change adaptation in the literature are discussed. This is needed to assess which implementation approach (top-down or bottom-up) is more compliant with the implementation of the climate change adaptation policies. The summary of the findings will be discussed in Section 2.7. The comparison between policy implementation theories, and findings of previous empirical studies which produces helpful guidelines for designing methodological frameworks in relation with the empirical phase of this research are presented in Chapter 3.

2.5.1 The Top-Down Approach

The top-down perspective is policy-centred and represents the view of policy-makers. It assumes that by setting up a correct governance structures, the pre-specified policy goals of the policy makers can be achieved (Paudel, 2009). 'Top-downers' are concerned with finding barriers that make it difficult for implementers to achieve the pre-defined goals of the program (Hill and Hupe, 2002). They argue that there is a direct link between implementation success and the cooperation between different organisations and departments at the local level (Paudel, 2009). Pressman and Wildavsky (1973), assert that in order for a policy to be successfully implemented in the manner anticipated by its designers it needs to be designed correctly and there has to be an effective chain of commands. Drawing on their top-down model, effective cooperation between all of the links in the implementation chain, between different agencies, organisations and departments is needed for a policy to be implemented successfully. In other words, the top-down approach assumes that the policy designer sets the goals for the policy which is implemented by the actors in the implementation chain. The implementation is difficult when there are multiple actors, and the effective (or non-effective) linkages between these actors are the main determinant in the success (or failure) of a policy implementation (Pressman and Wildavsky, 1973). Elmore (1979) and Hill and Hupe (2002) summarise the top-down approach as below:

> "It begins at the top of the process, with as clear a statement as possible of the policy-maker's intent, and proceeds through a sequence of increasingly more specific steps to define what is expected of implementers at each level".
>
> (Elmore, 1979, p.602)

> "If action depends upon a number of links in an implementation chain, then the degree of co-operation between agencies required to make those links has to be very close to a hundred per cent if a situation is not to occur in which a number of small deficits cumulatively create a large shortfall".
>
> (Hill and Hupe, 2002, p.44).

In this perspective, the policy implementation is seen as an administrative process (Meter and Horn, 1975). In other words, policy is the property of policy-makers at the 'top' and it is required to have a high degree of control over implementers at the local level to minimise the implementation deficit. Also the policy making and implementation are considered to be two separate phases (Tiesdell, 1999). According to Sabatier (1986), the top-down approach starts with a policy decision by high level actors (governmental officials) and then poses the following questions:

1- To what extent were the actions of implementing officials and target groups consistent with (the objectives and procedures outlined in) that policy decision?
2- To what extent were the objectives attained over time, i.e. to what extent were the impacts consistent with the objectives?
3- What were the principal factors affecting the policy outputs and impacts, both those relevant to the official policy as well as other politically significant ones?
4- How was the policy reformulated over time on the basis of experience?

(Sabatier, 1986, p.22)

The top-down approach makes a clear distinction between two different and important stages of the policy cycle (see Section 2.3.1), policy formulation and policy implementation. In this approach actors involved in the policy formulation set the targets for implementers and control the process of policy implementation and delivery at different levels. Supporters of this perspective argue that the top level policy makers are able to make such a detailed blue print by providing action plans to guide the bottom level actors during the implementation phase (Pressman and Wildavsky, 1973, Meter and Horn, 1975, Hill and Hupe, 2002). Matland (1995, p.147) outlined the top-down approach for policy implementation as follows: “make policy goals clear and consistent […] minimize the number of actors […] limit the extent of change necessary […] place implementation responsibility in an agency sympathetic with the policy's goals”. The following section describes the most important top-down theories and models for analysing the policy implementation.

2.5.1.1 Meter and Horn’s Model

Meter and Horn’s definition (Meter and Horn, 1975) of policy implementation clearly categorises them as members of the top-down group. They argue that policy implementation starts when goals and objectives of the policy have been established by prior policy decisions. They acknowledge Pressman and Wildavsky’s idea (Pressman and Wildavsky, 1973) that failure in policy implementation should not refer to the policy makers because the responsibility of policy makers is finished when legislation has been passed and funds are committed. They argue that the policy implementers are responsible for the failure (lack) of the policy implementation, and they conclude that the implementation research is related to those factors that contribute to the realisation of policy objectives defined by higher level decision makers (Meter and Horn, 1975).

Providing evidence from previous research, Meter and Horn (1975) highlight the implementer’s role in the outcome of the policy and attempt to link the accusation of policy implementation failure (defined as not achieving the intention of public officials’ statements or policies) to the lower level (local) actors rather than to policy makers. In Meter and Horn's view, the gap between the intention of the public officials and the policy is insignificant, and implementers need to pay more attention to the understanding of the goals and objectives determined by the higher level actors.

However, Meter and Horn used 'goal consensuses' and 'amount of change' as two key elements in categorising policy implementation. To do so, Meter and Horn do not explicitly describe how changing these policy dimensions can affect the implementation, but they develop the following hypothesis instead:

> "Implementation will be most successful where only marginal change is required and goal consensus is high. Conversely, where major change is mandated and goal consensus is low, the prospects for effective implementation will be most doubtful".
>
> (Meter and Horn, 1975, 461)

Meter and Horn's model emphasises the need for clear policy and objectives. They also pointed out that a good policy needs adequate resources in terms of funds or other incentives in order to motivate implementers and facilitate the administration. Hill and Hupe (2002) argue that Meter and Horn's model is helpful for those studying the implementation, but it cannot provide prescriptions for policy makers.

2.5.1.2 Gunn's Conditional Model

Gunn (1978) set 10 conditions and stated that satisfying these conditions will lead to perfect implementation of policy. Gunn's (pre) conditions are as follow:

1. External circumstances should not impose strict constraints to the implementing agency. For example the lack of high level supports from the government can affect policy implementation.

2. Available resources and time should be adequate.
3. Not only shouldn't there be overall resource constraints but the required resources (pecuniary and non- pecuniary) should also be available at each stage in implementation process.
4. The policy should be based upon a valid theory of cause and effect.
5. The links between cause and effect should be mostly direct.
6. There should be a single implementation agency whose success has not been linked to the functions of other agencies. If more stakeholders are involved, there should only be a few dependency relationships with minimal importance.
7. There should be an appropriate consensus regarding the defined objectives throughout the implementation process.
8. There should be a detailed division of responsibilities between all participants in correct sequence.
9. There should be regular communication and coordination between all of the players involved in the program.
10. Those in authority should be able to demand and obtain perfect obedience from other players whose coordination is needed for the policy implementation.

Ison and Rye (2003) evaluated the preconditions mentioned by Gunn by analysing the implementation of travel plans and road user charging measures. They argue that this model highlights the most important factors for a successful implementation. Ison and Rye identified the four most important preconditions of Gunn's framework in implementing the transport policies as follows:

1. Circumstances external to the implementing agency ,
2. The direct relationship between cause and effect ,
3. Single implementing agency, and
4. Sufficient resources.

In another study, McLaughlin and Krantzberg (2011) concluded that although “perfect implementation is an unreal concept” (p.394), Gunn’s preconditions can be considered in terms of systematically thinking about the factors affecting the success or failure of a policy implementation. However, Ison and Rye argue that this model and its preconditions do not completely cover the implementation process, most importantly it does not help decision makers in prioritising the elements of the process.

2.5.1.3 The Policy Implementation Framework

Sabatier and Mazmanian (1979, 1980 cited in Sabatier, 1986) introduced a conceptual framework for policy implementation after identifying a variability of legal, political and tractability variables impacting on the process of policy implementation. From a wide range of variables, they identified six “necessary and sufficient” categories of conditions to implement legal objectives effectively as follows:

(1) Clear and consistent policy objectives,
(2) Accurate causal linkages between objectives and actions,
(3) Use of a sympathetic agency with adequate resources and authority to implement the plan,
(4) Skilled and committed implementation managers,
(5) Public and stakeholder support, and
(6) A supportive socio-economic and policy environment.

Apart from the methodological criticism of Mazmanian and Sabatier’s model for analysing the process of policy implementation from the bottom-uppers’ viewpoint, their framework has also been criticised by other top-downers. According to Sabatier (1986), many examples of empirical research confirm that the emphasis that has been placed by Mazmanian and Sabatier on “*clear and consistent policy objectives*” is not persuasive. The second criticism on their framework is about its weakness in providing “a good conceptual vehicle for looking at policy change over periods of a decade or more” (p. 30). The following section discusses the main critiques of the top-down approach for the policy implementation.

2.5.2 Critiques of Top-Down Models of Policy Implementation

The top-down approach is criticised by scholars from different backgrounds mainly for neglecting the role of operational actors on the effectiveness of policy implementation (Hill and Hupe, 2002). Critics argue that, from this perspective, implementers do what policy-makers tell them and policy-makers control what implementers do in order to minimise the deviation from the goals of initial policy making. Thus, this approach clearly denies the decision-making role for bureaucrats and lower level actors (Tiesdell, 1999).

In addition, opponents of the top-down approach criticise it for its weaknesses in justifying symbolic policy making. In other words, they argue that sometimes policy-makers deliberately make the policies ambiguous, complex or even meaningless, and intend to demonstrate that they are working on the issue and seriously addressing the problem (Hill, 2005). For example, drawing upon the findings of a comprehensive literature review and semi-structured interviews in two case study areas in England, Bache et al. (2015b, p.19-20) conclude that “given the constellation of interests in local networks and prevailing economic conditions … the carbon reduction target [for transport sector] is best understood as a symbolic meta-policy”. Another study in which four case study areas in England and Scotland were carried out reveals that the emphasis of the policy-makers at all levels of the transport governance in delivery of the transport-related policies has switched from climate change mitigation and carbon reduction to economic growth and job creation (Bache et al., 2015a).

The top-down approach has been also criticised not only for paying too little attention on the role of lower level actors but also for assuming them as impediments (Sabatier, 1986). Critics argue that this attitude of top-downers makes them neglect the role of local officials, street level bureaucrats and the private sectors in promoting strategic initiatives. They conclude that top-down models are likely to underestimate (or even ignore) the strategies used by target groups and street level bureaucrats to use it for their own purposes. According to Paudel (2009), considering the centrally designed policies by the higher level actors, local organizations develop and implement their own programs.

Elmore (1979) argues that the top-downers' assumption about the policy makers' role in controlling the policy implementation process is a "noble lie" and then claims that both policy makers and policy analysts know that "most of what happens in the implementation process cannot be explained by the intention and directions of policy makers" (Elmore, 1979, p.603).

2.5.3 The Bottom-Up Approach

The Bottom-up perspective in contrast gives more critical role to local implementers in both policy formulation and implementation (Tiesdell, 1999). The supporters of this perspective argue that "a more realistic understanding of implementation can be gained by looking at a policy from the view of the target population and the service deliveries" (Matland, 1995, p.148).

According to Sabatier (1986) bottom-up approaches do not start the process with policy-making. This approach analyses the behaviour of actors involved at the local level regarding a particular issue and focuses on their strategies in pursuing their objectives (Sabatier, 1986). In other words, this approach has placed special emphasis on the behaviour of street-level bureaucrats and local operational level actors during the process of policy implementation.

Matland (1995) states that from bottom-up point of view, central decision makers are not able to control the implementers at the bottom. Central planning can only influence micro level (bottom) factors indirectly. Bottom-up protagonists argue that a wide range of variables at the bottom will lead to different implementation of the same national policy, and when the local implementers do not have a sufficient freedom to choose their strategies between alternatives the policy implementation is likely to fail. They, therefore, suggest that for preventing any potential failure in implementation, it is necessary to consider the local level implementers' view in the policy making.

Since the local actors have direct contact with the public, they have been considered to have a better understanding of what should be done as a result they have been placed at the centre of policy-making and political process (Paudel, 2009). In other words, they are assumed to be the real policy-makers (Lipsky, 2010). When a policy cannot be successfully implemented, bottom-uppers claim that central initiatives are not well adapted to local conditions (Paudel, 2009).

Although Michael Lipsky's influential book (Lipsky, 1980) was not published until 1980, his original theory about the "street-level bureaucrats" introduced in 1971 (Lipsky, 1971) was the main reason that Hill and Hupe (2002, p.51-2) call him as the "founding father of the 'bottom-up' perspective". Lipsky argues that "the decisions of street-level bureaucrats, the routines they establish, and the devices they invent to cope with uncertainties and work pressures, effectively become the public policies they carry out" (Hill and Hupe, 2002, p.52). According to Hill and Hupe, it is important to understand that the term "street-level bureaucrats" is not a factor that demonstrates the difficulty of policy implementation, rather this theory emphasises on the influential roles that "street-level bureaucrats" can play in the process of policy implementation. The following sections describe the most important bottom-up frameworks for analysing the policy implementation.

2.5.3.1 Implementation Structure Approach

The implementation structure approach, introduced by Hjern et al. (1981), has placed more emphasises on the network of local level actors. Hjern et al. linked the local level actors to other actors involved in the planning, financing and implementation of the policy (program) at the national and regional levels in order to form a structure for policy implementation. Conducting empirical research in Sweden and Germany, they conclude that efforts of individuals at the local level (bottom) are more important than the efforts of central government officials (top) in achieving success in policy implementation. According to this approach 'skills of individuals in the local implementation structure' plays an influential role in the success of the programme.

Hjern's network technique studies a policy problem by asking micro-level actors about their goals, activities, problems and contacts. It has been acknowledged in a wide range of the influential literature as a method in future implementation analysis to identify the relevant 'implementation structure' at different spatial levels (see for example Matland, 1995, Sabatier, 1986). This bottom-up approach assumes that poorly adapted central initiatives to local conditions are the main reason for implementation failure. For Sabatier (1986), this framework has at least four strengths:

(1) It produces an explicit and replicable methodology for identifying a policy network that includes interviewing key officials at the bottom, identifying their problems and chosen strategies to deal with each problem and continuing this process to find the actors within the highest level of the policy implementation network.
(2) Placing more emphasis on the actors' perceived problems will lead to assessing and comparing the ability of different strategies which higher level decision-makers have designed to tackle a specified problem.

(3) The ability of this approach in finding unintended consequences of the policies designed at the top (governmental) level.
(4) Because of the focus on a wide range of actors, this approach is better able to deal with strategic interaction over time (Sabatier, 1986)

Sabatier also found the following limitations for this approach:

(1) It over-emphasises the importance of local level implementers: this emphasis on the goals and strategies of bottom level actors may cause an under-estimation of the importance of indirect influence of central officials (top) over these goals.
(2) The networking approach cannot consider the initial efforts by decision makers in defining the policy structure.
(3) Lack of an explicit theory of factors; for Sabatier, this issue is a more fundamental limitation. He argues that this approach cannot pay sufficient attention to the direct and indirect parameters affecting the behaviour of participants, as a result, researchers may not be able to analyse them.
(4) This approach has not paid adequate attention to the implementation (carrying out) of policy and achieving the objectives defined by elected officials. But, it has focused on the perceptions and analyses of the actors.

2.5.3.2 Elmore's Backward-Mapping Approach

Elmore (1979, p.604) presents 'backward mapping approach' as follows:

> "The logic of backward mapping is, in all important respects, the opposite of forward mapping. It begins not at the top of the implementation process but at the last possible stage, the point at which administrative actions intersect private choices. It begins not with a statement of intent, but with a statement of the specific behavior at the lowest level of the implementation process that generates the need for a policy. Only after that behavior is described does the analysis presume to state an objective; the objective is first stated as a set of organizational operations and then as a set of effects, or outcomes, that will result from these operations."

The forward mapping approach talks about the assumption that essentially a hierarchal relationship is the main contributor in the success or failure of policy implementation, and that “clear lines of authority and control” are the main conditions in successful implementation and delivery of the policy. But in contrast, backward mapping is more related to the source of the problem (not policy). From this perspective, the ability of a complex system to solve a problem is more related to the discretion of actors at a more problematic level (bottom).

Although the main emphasis of Elmore is on the bottom-up approach and the role of low level actors involved in policy implementation such as the private sector since he uses both “backward mapping” and “forward mapping” perspectives; he is known as synthesiser by some scholars (Hill and Hupe, 2002, Matland, 1995). Matland (1995) argues that Elmore’s discussion about the “backward mapping” approach is useful and produces different suggestions for policy makers to consider lower level actors and target groups’ view in developing the planning strategies and action plans. However, he criticises Elmore’s work for not suggesting a specific model for determining the interrelationships between the different actors’ behaviour. Overall, the main criticism for the bottom-up models is the over-emphasis on the importance of lower-level implementers in decision making. Opponents argue that this overemphasis can ignore the important role of national level organisation in applying the integrated approach for addressing the multi-level or cross-sectoral problems (Sabatier, 1986, Paudel, 2009).

Another criticism of this approach is from the viewpoint of standard democratic theory (Paudel, 2009). Critics argue that, in the democratic system, the process of implementation should be exercised and controlled “… by actors whose power derives from their accountability to sovereign voters through their elected representatives.” (Matland, 1995, p.149).

Birkland (2010, p.272) argues that the study about policy implementation and the debate between the top-downers and bottom-uppers will continue "as long as policies fail, or appear to fail". Both top-down and bottom-up approaches have their own merits and today scholars acknowledge both and argue that a mixed method (which combines both top-down and bottom-up approaches) might be used (Hill and Hupe, 2002, Bache et al., 2015b). Although there were some disagreements between scholars on when the implementation process starts and ends, they unanimous that the process of policy formulation and implementation is a chain of events (Barrett, 2004).

In the context of climate change adaptation, Urwin and Jordan (2008) argue that the top-down approach is appropriate in exploring the coordination and interplay between actors defined at the written content of policies. By contrast, the bottom-up approach is a useful method to examine the extent to which policy affects sectoral actors' perceived ability to respond to climate change. Urwin and Jordan conclude that when climate change adaptation policies are being implemented by combination of local and national level actors, giving a prioritisation role to national level and organising their own planning role to local implementers will lead to better adaptation to climate change.

Seeking to understand how the UK's climate change mitigation targets in transport sector are translated into local actions, Bache et al. (2015b) argue that the top-down approach is most useful when a researcher is interested to assess the effect of a particular central government policy. And the bottom-up approach is relevant when the researcher investigates the different effects of the same policy in different places. As discussed in Section 2.8, climate change adaptation is a devolved matter meaning that each administrative region (England, Scotland, Northern Ireland and Wales) is responsible to develop and implement its own climate change adaptation policies. Hence the selection of case studies in different jurisdictions of the UK (see Chapter 3 for methodology and justification of the case study areas) will require a mixed method which combines the capabilities of both top-down and bottom up approaches. As another justification, as discussed in Section 2.6, previous studies about the implementation of climate change adaptation at the local level suggest that there are many factors compliant with each category of top-down or bottom-up approach which impede the process of adaptation. Thus the selection of a mixed method for analysing the implementation of climate change adaptation can provide us with a better and more complete picture of the process. The following section discuss the most prominent mix-method frameworks suggested in literature.

2.5.4 Syntheses

Considering both top-down and bottom-up approaches are simplistic as a result critics have attempted to combine the capabilities of these two approaches in order to develop a general causal theory which enables them to explain the success and failure of policy implementation (Paudel, 2009). Sabatier (1986) suggests that the merits of adopting a singular or combination of the top-down and bottom-up approaches depends on the type of issues or policies under investigation. According to Sabatier (1986) and Birkland (2010), the top-down approach for policy analysis is the best where there is a well-structured policy for the situation, or the policy analysts have limited time and resources for doing the implementation research and the bottom-up approach is the best when the researchers are interested to investigate the dynamics of local implementation.

Similarly, Matland (1995, p.152-3) argues that choosing the appropriate approach is mainly dependent on "a set of parameters that describes the policy context". Berman (1980) argues that there are some dimensions and variables that policy designers are not able to change or influence including the technology, institutional setting and environmental stability, etc. Berman concludes that the top-down policy model works best in situations that have a stable environment, certain technology, low conflict in the establishment of goals and tightly coupled institutional settings (including clear policy and mechanism). In contrast, when the technology is uncertain and the institutional setting is loosely coupled, Berman suggests choosing the bottom-up approach (Berman, 1980). This section discusses the most important frameworks developed by the most widely recognised scholars for combining the top-down and bottom-up approaches.

2.5.4.1 Advocacy Coalition Framework (Belief System)

Despite Sabatier's previous studies where the implementation of policy was from the top-down view, his article published in 1986 is an important work in combining both top-down and bottom-up approaches. Sabatier argues that the inability of previous studies to analyse policy implementation is related to defining short time-frames (4 to 6 year) which have missed many critical features of public policy-making, and suggests a 10 to 20 year period to be defined for analysing policy implementation.

Sabatier's Advocacy Coalition Framework (ACF) starts from the bottom of implementation chain in order to map the network of actors (see section 2.5.3.1) and find the objectives as well as the strategies employed by each actor to achieve these objectives. Mapping the actors in this method is not limited to formal actors, and involves formal actors as well as those actors who could indirectly play an important role during the policy implementation process. In order to consider the top-downers' view and to use the advantages of this perspective Sabatier includes two factors in his framework: one represents stable variables and the other represents dynamic variables. In this framework both sets of variables can affect the constraints and resources of subsystem actors (Sabatier, 1986, Sabatier, 1998).

According to Sabatier 'advocacy coalitions' includes all of the public and private actors who have the same beliefs. Sabatier argues that in modern industrial societies analysing the policy implementation should not be limited to a "specific governmental organization"; however, it is necessary to consider a "policy subsystem". He defines policy subsystems as "those actors from a variety of public and private organizations who are actively concerned with a policy problem or issue" (Sabatier, 1986, p.40).

The main contribution of Sabatier in this framework is his original idea about the policy subsystem, coalitions and actors which are mainly drawn upon the bottom-up perspective. Sabatier (1986, p.40) assumed that actors form a number of advocacy coalitions, and members of each coalition "share a set of normative and causal beliefs on core policy issues" (bottom-up viewpoint) and aim to further their own objectives and translate their own beliefs into governmental programs (rational top-down viewpoint – see Section 2.3.2). The power of a coalition in the policy subsystem is directly related to the extent to which the coalitions' beliefs have been translated to the program, or to the extent to which the program incorporates the beliefs of that coalition (Hill and Hupe, 2002, Sabatier, 1998). In order to reduce the conflict between the coalitions, this framework introduces a third group of actors, 'policy brokers' in order to help the parties reach a reasonable solution (Ingold, 2011).

One or more governmental action programs and policy outputs are produced at 'collective choice level' and 'operational level' respectively. Sabatier (1986, p.42) states "major alterations in the policy core will normally be the product of changes external to the subsystem particularly large-scale socio-economic perturbations or changes in the system-wide governing coalition". However, secondary aspects are changeable, and experience and revision of policy objectives motivate coalitions to change their beliefs and bring feedback loops in the policy subsystem (Ingold, 2011, Sabatier, 1998).

The advocacy coalition framework has been widely used for analysing the implementation of climate change-related policies (Szarka, 2004, Meijerink, 2005, Ingold, 2011) and sustainable transport policies (Hysing, 2009, Niederberger, 2005). Matland (1995, p.152) accepts Sabatier's framework as a "legitimate method for studying public policy", however, argues that this framework is not compatible with the Sabatier's definition for the policy implementation and states that "Sabatier's definition of implementation … does not appear to be about the same process. A policy field followed over many years can change so radically that it bears little resemblance to its initial form. If implementation research is to retain a meaningful definition, it should be tied to a specific policy rather than to all actions in a policy field".

2.5.4.2 Matland's ambiguity-conflict model

Matland (1995) reviewed the previous works on policy implementation from different perspectives (top-down, bottom-up and existing synthesised approaches) and presented the "ambiguity-conflict model" (Table 2-2).

Table 2-2: Matland's Ambiguity-Conflict Matrix (Matland, 1995)

		CONFLICT: Low	CONFLICT: High
AMBIGUITY	Low	Administrative Implementation **Resources**	Political Implementation **Power**
	High	Experimental Implementation **Contextual Conditions**	Symbolic Implementation **Coalition Strength**

Matland (1995) criticises some of the previous works (for example O'Toole, 1986), for suggesting many factors affecting the implementation process without presenting an appropriate structure. Matland argues that previous works have not sufficiently identified the underlying characteristics of the policies, and states that O'Toole's (O'Toole, 1986) argument about the contradictory recommendations of different literature regarding policy implementation can be answered by paying more attention to the policy context. For Matland, 'policy conflict' is an important factor that leads to implementation failure. 'Policy ambiguity' is another factor affecting the implementation of policy. Matland divides this factor into two categories; 'ambiguity of goals' and 'ambiguity of means'. As mentioned before, for top-downers clear goal and objective are of the main conditions to successful policy implementation. Matland argues that goal 'conflict' and 'ambiguity' often are negatively correlated, and states that the "… clearer goals are the more likely they are to lead to conflict … [a]s the policy became more explicit, existing actors became aware of threats to their turf and acted to limit the scope and range of proposed policy changes to maintain existing patterns of bureaucratic power and structure" (p.158).

2.6 Barriers to Implementation of Climate Change Adaptation Policies

In the previous sections of this chapter, the most important theoretical frameworks of policy implementation were reviewed and the most critical variables which are considered in each framework were discussed. In this section the main barriers for the implementation of climate change adaptation policies highlighted in empirical studies are presented. Drawing upon the recent articles published about climate change policy and governance, this section discusses the barriers that urban climate change adaptation governance faces during the implementation of adaptation policies or measures. These barriers have been divided into five categories; scientific barriers, institutional barriers, economic barriers, political barriers and finally social and behavioural barriers.

2.6.1 Scientific Barriers

Climate change literature shows that the impacts of climate change are unavoidable. However, despite the improving knowledge on climate change, the severity and frequency of different impacts still have remained uncertain (Tavasszy et al., 2016). Uncertainty about climate change has at least three reasons (Turnbull et al., 2011):

1- Uncertainty about the level of GHG emissions,
2- Uncertainty about the responses of the Earth's climate to increased GHG emissions, and
3- Existence of other natural variations (such as El Nino southern oscillation) which can be combined with the impacts of climate change.

Consequently, decision making on climate change adaptation is not easy as decision makers have to address the uncertain impacts of climate change (Füssel and Klein, 2006, Pilli-Sihvola et al., 2016). A large amount of uncertainties about the potential impacts of climate change, and unpredictable cost of adaptation have reduced the reliability of the rational cost-benefit analysis particularly when planners are developing strategies for a long term projects (Fröhlich and Knieling, 2013) which is the case for transport infrastructure. Transport infrastructure projects including the road, bridges and rail are usually designed to be operational for more than a century. Consequently, a small error in predicting the future impacts can have irreparable effects in the next decades. That is why cost-benefit analysis could not be effectively taken into consideration in climate change policy making. However, even the most influential literature is not free of criticism. The Stern (2007) review assumption about the discount rate and interest rate has been widely criticised. Some critics argue that Stern's review is over-estimating the damage of climate change impacts (Cole, 2008, Neumayer, 2007, Pielke Jr, 2007). In contrast, a re-assessment of UNFCCC's estimates after about 30 years shows that the assumptions about the cost of climate change impacts are substantially under-estimated (Parry, 2009). Likewise, the IPCC's warming predictions are criticised by researchers. Allen et al. (2009) show that the actual warming rate of the earth surface is greater than the predicted warming based on the IPCC's climate change scenarios.

Hence, it is obvious that policy makers at different levels of governance need to receive clear information about climate change and its impacts from higher level organisations or scientific communities to tackle the impacts of climate change. Moreover, according to Carter (2011) since some climate change impacts (for example heat waves) are of a cross boundary nature, it is necessary to support local actors within a higher level strategic framework. According to Henstra (2012), lack of information at the local level is one of the greatest challenges that decision makers face in developing local policies in order to respond to climate change. They need to make policies and implement measures for tackling the uncertain impacts of climate change without having clear information about the magnitude and severity of them.

This becomes more problematic when the decision makers are planning to integrate climate change adaptation policies into transport policies. Planning of large-transport infrastructure projects is a political-economic task because planners intentionally misrepresent costs, benefits, and risks in order to increase the likelihood of their own projects for gaining approval and funding (Flyvbjerg, 2007, Cantarelli et al., 2012, Flyvbjerg et al., 2002).

The role of actors at higher levels of governance in providing local level actors with detailed guidelines and required information has been highlighted in the literature (Smith et al., 2009, Mazmanian et al., 2013). The manner in which climate change related information is generated can make a significant difference in supporting decision-makers (Hanger et al., 2013). Clear guidance helps both implementers in the delivery process and government in the measuring the progress (Brouwer et al., 2013).

In this regard, a survey study in Norway shows that unfamiliarity with existing data on climate change is the main barrier that local governments have perceived in the process of adaptation to climate change (Amundsen et al., 2010). Similarly, a study in South Africa has found that limited capacity for policy implementation is one of the main challenges of local government officials in addressing the urban flood risk (Fatti and Patel, 2013). This means that firstly, national governments should provide local governments with clear and intelligible guidance; secondly, local governments need to employ climate change experts; and finally, both national and local governments need to have a strong relationship. The latter has benefits for local and national governments. The national level will guide the local level and local level will give feedback to the national level for consideration in the future guidelines (Hanger et al., 2013). Fünfgeld (2010) and Amundsen et al. (2010) argue that GIS-based climate change vulnerability maps are very useful for reviewing the impacts of climate change at the local level. However, local level actors should be provided with the information which they are familiar with. For example, from the local level actors' point of view, climate scenario maps are not helpful, but flood or landslides maps are more beneficial (Amundsen et al., 2010).

Although local governments need to have sufficient information about climate change impacts in their regions, but giving more scientific information to local actors can also be an obstacle for them because they will find it very difficult to integrate this huge amount of information into their development programmes and decision making (Fünfgeld, 2010). Fünfgeld suggests that using a combination of top-down climate change projections and the bottom-up (local level) knowledge about the climate change risks can play a significant role in enabling local actors to implement climate change adaptation policies by making this information more believable to local governments. Lack of expertise at the local level decision making process (mainly because of lack of financial resources) can also play constraining role in assessing the vulnerability of local area to climate change impacts (Smith et al., 2009).

Lack of local level confidence about both the current ability of science to provide reliable insights into future conditions and the significance of climate change are important factors that hamper the delivery of climate change adaptation policies at the local level. The implications of this attitude is that the climate change adaptation will not be the priority of local governments or staff (Smith et al., 2009). In contrast, receiving information and experience from local level actors (local governments) and also scientists, business and civil society will help the government to design the policies based on this knowledge. This process can motivate local actors to be involved in the implementation of climate change adaptation policies developed at the higher levels of governance, and consequently can indicate the priority of national government about climate change adaptation in implementers view (Corfee-Morlot et al., 2011). As will discuss in Chapter 3 (methodology), this thesis will use Q methodology to obtain the attitudes of different transport stakeholders about the implementation and delivery of climate change policies at the local level. This method provides a unique opportunity to determine how the approach of the national level actors in providing the information (or climate change risk assessment) is correlated to the attitude of local level actors.

2.6.2 Institutional Barriers

High coordination between different actors at different spatial levels is necessary to implement climate change adaptation policies quickly and effectively (Fröhlich and Knieling, 2013, Measham et al., 2011). As a result of the multi-scale and cross-sectoral nature of climate change, high collaboration between different climate and non-climatic sectors is also mandatory (Fidelman et al., 2013, Celliers et al., 2013). Limited explicit guidance from national governments can exacerbate a lack of clarity about the breakdown of responsibility between local actors and public and private organisations (Smith et al., 2009, Urwin and Jordan, 2008, Chang et al., 2013). Furthermore, as highlighted by Knieling and Leal Filho (2013), collaboration between governmental and non-governmental organisations including business, civil society is the main factor in making effective climate change governance.

As a result of unclear assigning the roles and responsibilities, the local level actors will feel that the adaptation to climate change and also implementation and delivery of climate change adaptation policies are not priorities for the national government (Measham et al., 2011, Corfee-Morlot et al., 2011). This will persuade local governments and implementers to follow their own perceptions about national governments' thoughts, and they, therefore, will not change their processes to effectively adapt to climate change (Amundsen et al., 2010). "unclear and overlapping division of responsibilities complicates the implementation of the NAS [National Adaptation Strategy] not only through conflicting incentives but also through the financial constraints and competition for resources between sectors" (Biesbroek et al., 2010, p.446). Similarly, Smith et al. (2009) and Biesbroek et al. (2010) highlight the role of clear responsibilities as well as national guidance determined in the implementation of climate change adaptation policies. A study in Australia shows that the staff in the local governments with the responsibility for environmental issues are tasked by higher level governmental organisations to contribute in province infrastructure (Measham et al., 2011). This in turn has led to emergence of other constraints such as lack of staff resources.

According to Fünfgeld (2010), one important barrier in effective implementation of adaptation measures at the local level is that local governments are seldom responsible for either identifying climate change impacts or selecting between the measures as they look to the national government to set the adaptation agenda and allocate them their respective roles and responsibilities. Hence, a clear and strong agenda that specifies actor roles at different spatial levels can address climate change challenge effectively. Fünfgeld concludes that a multi-level governance framework that clearly determines the role of cities and provides adequate financing processes will help to overcome this barrier, and suggests that “convergence of top-down climate change science and policy guidance and bottom-up assessments of local climate risk and vulnerability” can effectively address the climate change (ibid, p.158).

Appropriate distribution of power between different actors at different levels of governance is an influential factor in implementing climate change adaptation policies (Bulkeley et al., 2011, Fröhlich and Knieling, 2013, Antonson et al., 2016). Simonsson et al. (2011) argue that limited power at the regional level in decision-making is a significant barrier for policy implementation. They liken the Swedish political system to an hourglass where the regional level is like the waist which has a limited power.

The literature suggests that national governments must give more power to local level implementers in developing local policies (Urwin and Jordan, 2008, Bajić-Brković et al., 2012, van Staden and Musco, 2010, Antonson et al., 2016, Howes, 2016). By doing so, local policy implementers (makers) will have more motivation to implement adaptation measures. Urwin and Jordan (2008) state that “a great deal of what takes place at ‘the street level’ is not and never will be completely determined by the formal aims of policies decided centrally” (ibid, 189). Hence, they suggest that national governments should prioritise the adaptation activities and then local governments formulate and implement the policies to address those areas locally.

The role of communication and participation between the actors at different levels has been highlighted in the literature (van Staden and Musco, 2010, Tanner et al., 2009, Howes, 2016). Local actors can find the required knowledge and information about the best adaptation processes through communicating with experts at the national and international level. In addition, local governments and even scientists can benefit from local knowledge about local climate change impacts and risks by involving local stakeholders and considering their perceptions about these risks to create a more powerful risk assessment tool to mitigate climate change impacts (Simonsson et al., 2011, Cote, 2011).

Furthermore, according to Simonsson et al. (2011), cooperation and networks between different stakeholders at different levels of climate change adaptation governance is needed to create an acceptable compliance between the local actors' perception of climate change impacts and decision-makers' perception of the available adaptation options. Their analysis shows that national and local governments, citizens, public authorities and also regional administration and organisations are the most important actors in the implementation of climate change adaptation policies. NGOs, universities and schools also play an important role in the process of adaptation. Fünfgeld (2010) reveals that pioneering cities in the issue of climate change adaptation have engaged local government staff, private sectors and other stakeholders in management and adaptation processes by involving them in the process of risk assessment. In other words, the top-down approach for the climate change adaptation, which gives the delivery role to local level actors in translating national policies, "misses the complexities of how spatial planning is becoming enmeshed in the multilevel governance of climate change responses" (Bulkeley, 2009, p.287).

Corfee-Morlot et al. (2011) argue that urban governance of climate change can effectively help in the design and implementation of climate change adaptation policies. Shifting from the government to governance model enables decision makers to work closely with local stakeholders and this will provide them with local knowledge which is necessary to be integrated into the policy and guidance. This can lead to a cost-effective adaptation to climate change impacts. Furthermore, Corfee-Morlot et al. (2011) conclude that national and regional governments should be well placed in the issue of climate change adaptation and should have more attention to empower local governments by providing financial, informational and technical supports.

2.6.3 Economic Barriers

Lack of adequate 'financial resources' have been highlighted as one of the main barriers in successfully adapting a system to climate change from the stakeholders' point of view (Urwin and Jordan, 2008, Moser and Ekstrom, 2010, Waters et al., 2014, Georgeson et al., 2016). Henstra (2012) argues that the allocation of limited human and financial resources is the main factor that hinders local decision makers when implementing expensive or intrusive measures. Within a political environment, the issue of scarce financial resource cannot motivate local decision makers to support climate change adaptation polices which bring immediate cost but long-term benefits. As a result, no- or low-regret strategies will be the main interest of decision makers across the scales and sectors during the integration of climate change policies into departmental policies (Bierbaum et al., 2013). Walker et al. (2014) argues that the integration of the climate change adaptation policies into local transport planning in England cities needs a more specific allocation of funding from planning contributions of developers, or from a national level.

The financing mechanism is an important issue in the effectiveness of climate change adaptation process. Comparison between National Adaptation Strategies (NAS) in different European countries shows that none of these strategies have mentioned how the financing mechanisms work or what the instruments are (Biesbroek et al., 2010). Evidence from empirical research shows that although in some cases national governments have expanded the department's mandates, these expansions are not matched with the budgetary or spending patterns (Craft et al., 2013). An unclear financing mechanism will have negative effects on the process of policy transfer especially between local public and private sectors. Private sector actors need to have sufficient and clear information about the financing mechanism to decrease their risk of investment (Fuchs, 2014, Corfee-Morlot et al., 2011).

A financing mechanism which takes equity issues into account has been highlighted as a requirement for a more inclusive form of climate change governance. Most of the literature suggests that the poorest groups or small business will experience further negative impacts of the climate change in the 21st century (Williams and Schaefer, 2013). Inequity in the allocation of available resources, mostly as a result of unaccountable decision-making at the local level, is another economic barrier for local actors working on climate change adaptation (Agarwal et al., 2012).

Climate change issue and its potential impacts have been emphasised within recent UK policies and research activities. But review of the recent literature shows that in practice climate change adaptation has not been recognised as a high priority problem among local decision makers since the lack of financial resources persuade them to place the adaptation on the bottom of their agenda (Walker et al., 2014, Wilson, 2006). There is some evidence to suggest that changes in socio-economic conditions can have implications for the process of climate change policy implementation. According to Henstra (2012) in the face of fiscal austerity, climate change (adaptation) issue will be considered to have a little importance at the local level consequently city governments will plan to manage their budget by 'focusing on the fundamentals' through shutting down the respective departments (climate change or environment department) or cancelling new staff positions. Such an attitude has led private sectors focusing on 'staying alive' as a business (Cote, 2011, p.17). This is in contrast to the emphasis on the crucial role of robust contractual mechanisms for public-private investment in assessing and addressing climate change impacts (Corfee-Morlot et al., 2011). According to Corfee-Morlot et al. (2011), there are a few number of public-private partnerships in the UK such as Club ViTeCC and Ouranos where the government should provide them with the required information (both scientific and budgetary) to carry cities forward in the process of climate change adaptation.

2.6.4 Political Barriers

Henstra (2012) argues that citizens' concern about climate change is the main motivate for placing climate change adaptation on the city policy agenda, and the long term nature of climate change adaptation action is the main barrier for a strong demand for action from citizens. Henstra asserts that disaster is the main factor that motivates citizens to demand for climate change adaptation action for example the August 2005 storm which disrupted transportation throughout the Toronto area and also Hurricane Juan and White Juan in Halifax have been determined as the main motivate for prompting a search for protective measures at local level. Henstra states that the "post-disaster period typically provides a short window of opportunity for advocates to propose new policies or changes to existing policies in order to address the risks highlighted by the event" (Henstra, 2012, p.187).

On the other hand, politicians' views about climate change can influence the views of members of the public. According to a public poll in the United States, there is almost 34% differences between supporters of Republicans (42% agree) and Democrats (76% agree) in whether they think that climate change is occurring or not (Dunlap and McCright, 2008).

Low public demand for adaptation and weak policy making capacity at the local level are other potential barriers that city governments face in developing adaptation policies (Henstra, 2012). Politicians usually prioritise issues that demand immediate attention and require scarce resources which is not the case for climate change adaptation. While the costs of adaptation are visible and immediate, the benefits are largely intangible in the short term as adaptation usually provides benefits after more than a decade (Füssel and Klein, 2006).

A study in Costa Rica shows that although people are concerned about climate change and its impacts and there is strong public support and acceptance for adaptation, but this support reduces significantly when the government wants people to pay for adaptation (Vignola et al., 2013). This issue is very important for adapting the transport sector to climate change since the lack of financial resources at the local level does not allow the city level decision makers to implement adaptation policies without increasing the contribution of local developers (Walker et al., 2014).

One of the most emphasised adaptation barriers in the literature is related to the conflict between short-term electoral cycles and long-term nature of climate change adaptation measures. As a result, decision-makers typically focus on the most pressing agenda items and invest in proposals that generate short-term returns (Henstra, 2012, Corfee-Morlot et al., 2011, Waters et al., 2014). Lack of public members' interest in the adaptation will cause (local or national) governments to allocate a lower importance to climate change adaptation in the priority list particularly when the benefits are apparent in the long term. Hence, the challenge of climate change adaptation "fits poorly with a four year electoral cycle, the two or three year tenure of ministers and senior officials, and the daily or weekly rhythms of everyday politics" (Meadowcroft, 2009, p.4).

2.6.5 Social and Individuals Barriers

In addition to the barriers discussed in previous sections, there are also behavioural characteristics that may influence the attitude of stakeholders at the local level. Social, moral and individual factors such as habits, social status, cultural values, religious and local traditions form another group of influencing factors in the process of climate change adaptation (Wolf et al., 2013, Haddad, 2005, Grothmann and Patt, 2005, Leonard et al., Corner et al., 2014, Adger et al., 2013).

This list can be extended by adding some other socio-demographic factors such as age, gender, education and family structure (García de Jalón et al., 2013).

According to Fatti and Patel (2013) historical relationships of distrust with public organisations can influence the risk perceptions of local residents. Lang (2014) argues that people's search behaviour and activity (about the cause and effects of climate change) increases by the increase of local weather fluctuations accordingly. The causes of climate change may be perceived by public members to be uncertain and therefore cause stakeholders to be reluctant in adapting their properties to the impacts of climate change (Adger et al., 2009, Arbuckle et al., 2013, Raymond and Robinson, 2013, Anderegg et al., 2010, Capstick and Pidgeon, 2014). Although awareness raising has had a crucial role in initiating climate change adaptation policies in recent years, but evidence shows that still a low level of organisational concern for climate change adaptation is a barrier to this complex process (Craft et al., 2013).

A study by Amundsen et al. (2010) reveals that experiencing the impacts of climate change at the local level is a trigger in putting the climate change adaptation in the city policy agenda. However, local governments have considered specific impacts of climate change (in this case extreme precipitation and flooding) as the main impacts of climate change in their jurisdictions. As a result, appropriate measures and robust approaches have not been employed to assess climate change impacts and address them for increasing the resilience of infrastructures or buildings. Amundsen et al. (2010) concludes that these types of adaptation activities are mostly reactive and will unlikely lead to resiliency since addressing uncertain climate change and tackling its unclear impacts needs a suitable planning process. Thus it is required that city level decision makers rethink about the perceived and actual levels of risk that they face (Waters et al., 2014). Table 2-3 summarises the key obstacles to the planning and delivery of climate change adaptation policies.

Table 2-3: Key obstacles to local adaptation action

Technical or scientific	1- Scientific uncertainty 2- Lack of scale relevant scientific or technical information 3- Too much information 4- Lack of technical capacity or access to expertise
Jurisdictional and institutional	5- Lack of mandate to address climate issues from higher levels of governance 6- National or regional laws, rules or regulations that lead to mal-adaptation and increase vulnerability over time 7- Ill-adapted institutional designs to convene or coordinate across relevant issues (vertically and/or horizontally) at different spatial levels 8- Concentration of power at the national level and giving the delivery role to local actors
Political	9- Local authorities "too close" to different interests 10- Short-term regulatory focus 11- Lack of willingness to accept costs and behavioral change
Economic and budgetary	12- Distribution of perceived and real costs and benefits 13- Lack of resources or funding to address the problems identified 14- Unclear financing mechanism
Social and individual	15- Inadequate understanding or ignorance of climate change risks 16- Individual characteristics, such as habit and perception of risk 17- Perceived low levels of organizational concern for climate change at the local level

Source: adapted and changed from (Corfee-Morlot et al., 2011)

2.7 Climate Change Adaptation Policy Frameworks

Climate change adaptation policy is a devolved matter and devolved administrations are responsible to adapt their jurisdictions to the impacts of climate change (DEFRA, 2009). The following sections discuss the different adaptation policy frameworks in England and devolved administrations, Scotland, Northern Ireland and Wales.

2.7.1 England

Climate Change Act 2008 (CCA 2008) is a legal long-term framework that established initiatives on both mitigation and adaptation (DECC, 2008). Despite the previous climate change programmes in which the government had focused on the mitigation, CCA 2008 has placed more emphasis on the adaptation (EAC, 2010). Regarding mitigation, the Act changed the UK's CO_2 reduction target from 60% (defined in the UK climate change programme 2006) to 80% by 2050; the 1990 level was considered as baseline. An independent body called Committee on Climate Change (CCC) was established to counsel the Government for the carbon budget and estimate the progress of climate change. On adaptation, it has asked government to (Bayliss et al., 2009, p. 16, Parliament, 2008):

- Assess climate change risk for the UK every five years. First Climate Change Risk Assessment (CCRA), was published in January 2012 (DEFRA, 2012g);
- Based on the CCRA, to publish and update a National Adaptation Program to address those risks.
- Establish a new Reporting Power for the government to ask public authorities and statutory undertakers (companies such as water and energy utilities) to assess the risks and setting out the action plans;
- Produce Statutory Guidance and publish strategy for undertaking the risk assessments and drawing up the adaptation action plans.
- Create an Adaptation Sub-Committee (ASC) of the independent Committee on Climate Change (CCC) in order to oversee progress on the Program and advice on the Climate Change Risk Assessment.

In order to assess the UK preparedness to climate change impacts, Adaptation Sub-Committee (ASC) was established in 2009. The ASC is responsible to respond to the requests from national authorities on adaptation (Parliament, 2008, section 56), provide advice and scrutiny on the Climate Change Risk Assessment (section 57) and report on progress with the National Adaptation Programme (section 59). Although up to now the committee has published several reports about the progress of preparation of the UK and devolved administrations to climate change, but most of them are related to the issue of climate change mitigation.

Co-ordinated by Defra, the Cross-Government Adapting to Climate Change (ACC) Programme was set-up in 2008 to manage the progress on adapting to climate change already being led by variety of public sector organisations in the UK (Parliament, 2008). The aim of this programme is to embed adaptation into government processes and system through supporting capacity building and providing required information to help organisations adjust their action plan to the future climatic change and consequently increase the resilience of their sectors in a sustainable manner (Bayliss et al., 2009). Objectives of the programme are (DEFRA, 2011a):

- To develop a more robust, credible and comprehensive evidence base about the climate change impacts.
- To raise awareness of the need to take action now and help others to take action.
- To work across Government at different levels (national, regional and local) to make sure that the Governments' concern about adaptation to climate change is embedded into policies, programs and systems.
- To measure success and advice authorities to ensure effective delivery of the Program's objectives.

A Program Board comprised of representatives from the central Government Departments direct the ACC Programme (Bayliss et al., 2009). From October 2011, the ‘Environment Agency’ became the DEFRA’s main agency for adaptation advice in England to help key sectors build resilience to the potential impacts of climate change (Environment-Agency, 2012).

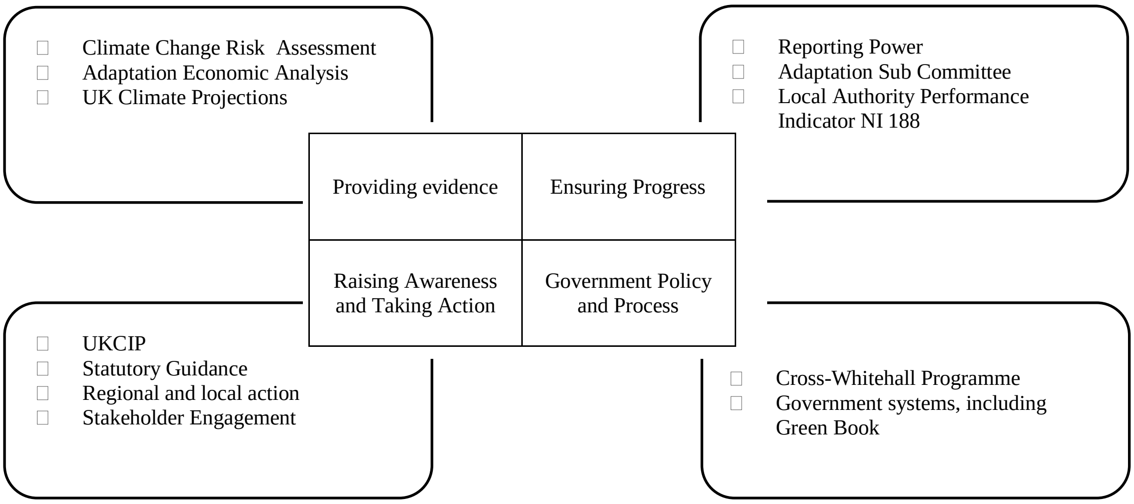


Figure 2-2: Work streams in the ACC Programme

Reference: (Bayliss et al., 2009)

Figure 2-2 shows work-streams in the ACC Programme. Synergy between mitigation and adaptation has not been mentioned explicitly in the ACC Programme. However, this programme has a set of core principles. One of them is sustainable development which covers the issue of mitigation. “*Adaptive action should follow the principles of sustainable development, in particular ensuring that the needs of the natural environment, society and the economy are all acknowledged and protected*” (DEFRA, 2008 , p. 27 & 32, Davoudi and Mehmood, 2010).

2.7.2 Scotland

Climate Change Act (Scotland) 2009 (CCSA 2009) is a legal long-term framework that establishes initiatives on both mitigation and adaptation and came into force in August 2009 (Legislation, 2009). On mitigation, this act set two ambitious targets to decrease emissions by at least 42% and 80% lower than the 1990 baseline by 2020 and 2050 respectively (DEFRA, 2012b).

The CCSA 2009 aims to achieve the adaptation goals in Scotland in a number of ways: Scottish Adaptation Programme, Annual Report on Progress, Duties for Public Bodies and Land Use Strategy (DEFRA, 2012b). CCSA 2009 committed the Ministers to lay an adaptation programme in the Scottish Parliament. These Programmes comprises the Departments' adaptation objectives, policies and proposals. Climate Change Risk Assessment (CCRA) published in January 2012 and now Ministers (including the Minister of Housing and Transport) are preparing their proposals. CCSA 2009 also committed the Ministers to report their progress annually about the adaptation activities (implementation of objectives, proposals and policies) in their areas. Moreover, according to the Act, an independent assessment of the progress will be provided regularly by the UK Committee on Climate Change's Adaptation Sub-Committee (CCC-ASC). The act has also placed a task on all public bodies to exercise their functions "*in a way best calculated to deliver any statutory adaptation programme*" (ASC-CCC, 2011, p.25).

Scotland's Climate Change Adaptation Framework was published in 2009. The aim was to "*increase the resilience of Scotland's communities, and the natural and economic systems on which they depend, to the impacts of climate change*" (Scotland, 2009, p.3) through:

- Raising the awareness about climate change impacts, both risks and opportunities,
- Supporting the stakeholders with the required information and skills,
- Integrating adaptation into wider public policy and regulation in order to address climate change issues.

Scotland's Adaptation Framework identified twelve sectors to develop 'Sector Action Plans' and suggested six following principles in developing them:

(1) Considering mitigation,
(2) Building broader resilience: both short and long-term challenges[1],
(3) Informing the adaptation process by a cycle of review and action,
(4) Integrating adaptation into existing development and implementation practices,
(5) Implementing the adaptation at an appropriate scale, and
(6) Encouraging partnership and avoiding restricting interested parties.

In transport sector, the key policy is the National Transport Strategy (NTS). Published in 2006, NTS provides a 20 year vision for Scottish Government. Key strategic outcomes are:

- Improving journey times between cities, town and global markets
- Mitigating climate change
- Improving quality, accessibility and affordability of transport

Scottish 'Transport Sector Action Plan' was published in 2011. According to this Action Plan, Transport Scotland as the leader on Scottish strategy and policy for transport overall is seeking to lead the way in adapting to climate change (Scotland, 2011).

2.7.3 Northern Ireland

Under the Northern Ireland Act 1998, Northern Ireland Executive is responsible for adapting Northern Ireland to climate change in all transferred policy area (DEFRA, 2012a, Parliament, 1998). In Northern Ireland, Department of the Environment (DOE or DOENI) is the leader on climate change agenda through its Climate Change Unit. Under the section 60 of Climate Change Act 2008, the relevant Northern Ireland's departments are committed to lay the programmes

[1] Short term (5-10 years), medium-term (20-30 years) and long-terms (30-40 years)

before the Northern Ireland Assembly[2]. These programmes will include defining (Parliament, 2008, DOENI, 2012a):

(1) Departments' objectives in relation to climate change adaptation
(2) Departments' proposals and policies for addressing the defined objectives
(3) The time-scale for introducing those proposal and policies.

The Cross Departmental Working Group on Climate Change[3] (CDWG CC) is the Northern Ireland Executive's programme to mitigate climate change and its potential impacts in Northern Ireland. On adaptation, the Adaptation Sub Group within this programme is committed to (DEFRA, 2012a, DOENI, 2012b):

(1) Support the preparation of the UK-wide Climate Change Risk Assessment (CCRA);
(2) Support the preparation of the UK-wide Economics of Climate Resilience (ECR) study;
(3) Evaluate climate change impacts (both risks and opportunities) for Northern Ireland and implement the Cross-Departmental Programme (adaptation and mitigation);
(4) Annually review the progress of Programme and report it to the CDWG CC; and
(5) Make decisions and/or recommendations on wider climate change adaptation issues as appropriate.

2.7.4 Wales

Under the part 4 of the Climate Change Act 2008 (adaptation), the Welsh Ministers have the power to outline their risks from climate change and respond to its impacts. The Welsh government has planned to respond to the Climate Change Act

---

[2] "[i]t is expected that a Northern Ireland Adaptation Programme will be laid before the Assembly by late 2012". See http://www.doeni.gov.uk

[3] Formerly, Cross-Departmental Working Group on Greenhouse Gas Emissions, remit to included adaptation to climate change.

2008's requirement by "Preparing for a changing climate" in five parts: Starting, Investigation, Planning, Implementing, and finally Monitoring and Reviewing. Part 1 (Starting)[4] and Part 2 (Investigating)[5] of the Welsh government's adaptation guidance have been published. Adaptation sub-group of Climate Change Commission for Wales was established in 2008[6] and was one of the four sub-groups contributed in publishing the "Climate Change Strategy for Wales" (Welsh-Assembly, 2010a). This strategy addresses both mitigation and adaptation. On adaptation, this strategy introduced an Adaptation Framework to address the vulnerability to climate change in three pillars (ibid, p.89):

(1) Building the evidence base to understand climate change impacts and consequences
(2) Mainstreaming adaptation to build adaptive capacity.
(3) Communicating on adaptation to ensure that the planners and decision-makers at all levels are aware of climate change impacts and have needed information about the tools to utilise them in their decisions.

In addition to the above mentioned strategy, Welsh Government published the "Adaptation Delivery Plan" in 2010 (Welsh-Assembly, 2010b) and defined 24 actions within six categories: strategic actions, natural environment, infrastructure, communities, health and business and tourism. Under the Action 15 that is placed in the 'mainstreaming adaptation' pillar, the Welsh Assembly Government became committed to "*[r]eview the resilience of the transport infrastructure to the effects of climate change and develop a programme to address risks*" by 2011 (ibid, p.9). The desired outcome is:

(1) To review the resiliency of motorway and trunk road infrastructure
(2) To understand the risks of climate change on Wales's road network
(3) To develop a vision of how Wales's transport networks need to be changed to adapt to consequences of climate change.

---

[4] http://wales.gov.uk/docs/desh/publications/111006preparingpart1en.pdf
[5] http://wales.gov.uk/docs/desh/publications/111006preparingpart2en.pdf
[6] http://wales.gov.uk/topics/environmentcountryside/climatechange/tacklingchange/strategy/commission/?lang=en

The Welsh Assembly Government (WAG) published 'Planning Policy Wales' in 2011. Climate change adaptation has been considered in this policy, and planners and decision makers need to take it into account in their planning. WAG has defined a 30-40 year period for climate change risks to be considered in Wales planning. Welsh government also guide local planning authorities by Technical Advice Notes (TARs)[7]. Among 21 published TARs, TAR 14 (Coastal Planning 1998) and TAR 15 (Development and Flood Risk 2004) are related to climate change adaptation. At the local level, all Welsh local governments signed the 'Welsh Commitment to Address Climate Change' and are committed to reduce the greenhouse gas emission and decrease the risks of climate change in in their areas[8].

2.8 Road Transport Governance Arrangements

The current devolution of the transport powers between different actors date back to 1998. In response to the traffic growth, pollution and decline in bus and rail service, the British government issued a White Paper in 1998, "*A new deal for transport: better for everyone*" in order to enhance the sustainability in transport sector (DETR, 1998, Akram et al., 2011). This white paper identified the need for introducing sustainable and environmentally friendly forms of transport such as public transport, walking and cycling, as well as defining the future direction and policy agenda of national government with respect to transport system.

According to the White Paper the rational of 'predict-and-provide' approach is not a desirable – or possible – approach for addressing the problem of car growth and congestion. Underlining the need for improving the existing sustainable transport, it suggests that giving more power to local authorities in decision making can lead to more success in delivery of the sustainable transport. Highlighting the role of

[7] See http://wales.gov.uk/topics/planning/policy/tans/?lang=en
[8] See http://www.wlga.gov.uk/download.php?id=1118&l=1

private sector and incentives, it then stresses the importance of public-private partnership and integrated transport policy towards sustainability (Goodwin, 1999, Hine and Preston, 2003). According to Akram et al. (2011), the current transport governance models in the UK are a result of the power devolution for managing the passenger transport in order to decrease the car use. The White Paper explicitly emphasised on the maintenance and management of the road system rather than building more new roads to accommodate the growth in traffic. Figure 2-3 shows the arrangement of institutions in the transport governance network in the UK and devolved administrations. The following sections discuss the road transport governance arrangements in the UK's different jurisdictions.

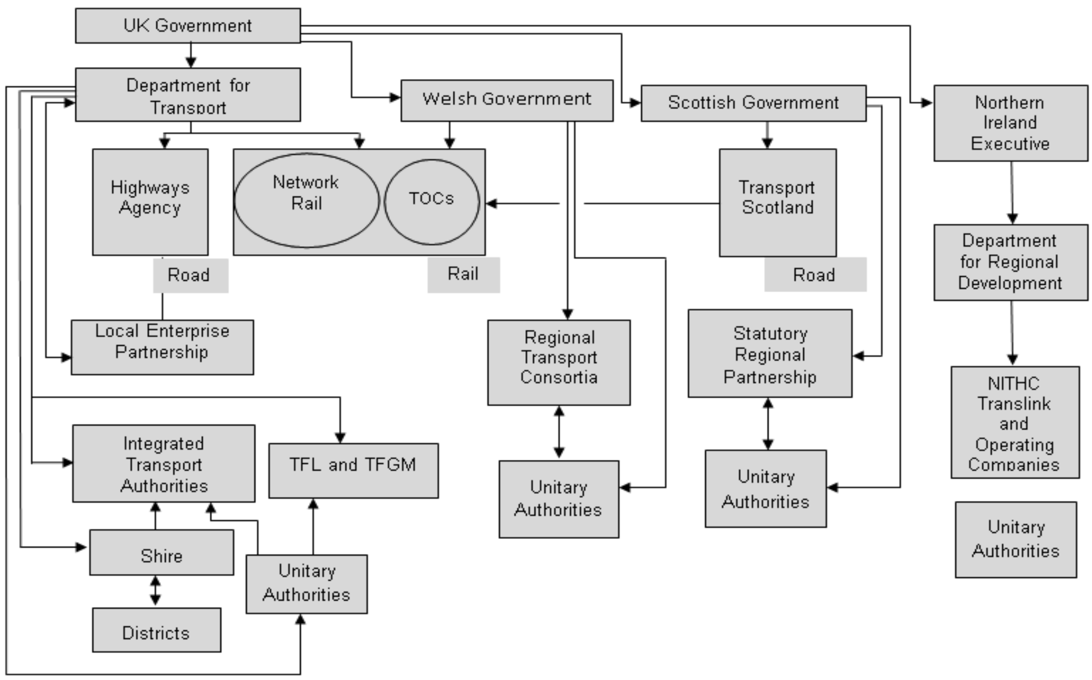


Figure 2-3: Simplified transport institutional arrangement in the UK, Wales, Scotland and Northern Ireland

Reference: (Scotland and England are adapted and modified from Marsden and Rye (2010))

2.8.1 England

Department for Transport (DFT) is the main actor within the UK's transport governance network. DFT's responsibilities include policy development for all of the main modes of transport, road, rail, air and water transport (Marsden and Rye, 2010). DFT is also responsible for the delivery of reserved transport matters (such as safety issue) in Scotland and Wales. DFT (2007, p.23) defines five inter-related goals for transport, GDP growth, CO_2 emission reduction, healthy transport forms, well-being of total community and fairer society. Department for Transport co-operates with other national/local organisations in order to deliver these objectives on the ground.

DFT co-operates with the Department for Business, Energy & Industrial Strategy (DBEIS)[9] which is responsible for climate change mitigation policies and their integration with other departmental policies. Department for Environment, Food and Rural Affairs (DEFRA) has the responsibility to overlook the integration of climate change adaptation policies and other departmental policies[10]. The HM Treasury, as the UK's finance and economics ministry, works with DFT through allocating budget and funds to transport projects[11]. Department for Communities and Local Government (DCLG) is the connector department between DFT and local authorities with respect to the integration of transport and land use planning policies [12].

In 2010, DFT published '*Building Resilience to Climate Change: An Adaptation Plan for Transport 2010-2012*" and updated it in 2011 to meet the strategic aim i.e. 'transport that works for everyone'(DFT, 2010a, DFT, 2011b). As part of the Cross-Government Adapting to Climate Change Programme, two year cross-departmental Infrastructure and Adaptation Project (the Project) was set up in

---

[9] Formerly, Department of Energy & Climate Change (DECC)
[10] http://www.defra.gov.uk/environment/climate/adapting/
[11] http://www.hm-treasury.gov.uk/about_equality.htm
[12] https://www.gov.uk/government/organisations/department-for-communities-and-local-government

2009. Transport sector was one of the four sectors (energy, ICT, transport and water sectors) considered to be studied. The aim of this project was to enhance the long term resilience of new and existing infrastructure to future climate change impacts (DEFRA, 2011b). According to DEFRA (2012c), DFT is also working to embed adaptation in decision making through Nation Policy Statements (NPSs)[13].

In road transport, the Highways England[14] is the executive agency of the DFT and after DFT is the most powerful stakeholders in the UK's road transport system. The DFT's policies and objectives should be considered by Highways England during the supervision, operation and development of the trunk road network (DFT, 2009, p.6-7). Out of a total of 284,000 Km road network in England, only 10,500 Km (below 4%) is under the control of Highways England. However, trunk road network in England carries 34% of all traffic and 67% of freight (HA, 2012). DFT was funding the Highways England up to £6bn until 2014 for improvement of major roads to support economic and housing growth and improve safety (DFT, 2007).

In 2009, the Highways England published its own adaptation strategy, "*Climate Change Adaptation Strategy and Framework*" based on the reviewing the HA's own works and several other organisations' reports such as IPCC, Stern and UKCIP. This framework was prepared by consulting with a stakeholder group comprising members from Highways England, DEFRA, Met Office and other individuals (HA, 2009). HA's guidance related to climate change adaptation are "*Maintaining Pavements in a Changing Climate*" and "The effects of climate change on highway pavements and how to minimise them" (Willway et al., 2008, Willway, 2008).

Highways have been categorised as "*Nationally Significant Infrastructure Projects (ISIPs)*" (Parlimant, 2008, see Part 3). Established in 2009 by Planning Act 2008,

13 Introduced by the Planning Act 2008, Ministers have the duty to ensure that the Departments' objectives in NPSs are in line with the Objectives of the Act, including adaptation to climate change.
14 Formerly: Highways Agency

the Infrastructure Planning Commission (the Commission or IPC) was a non-departmental public body for assessing the applications for order granting development consent in England and wales. This commission was abolished in April 2012 and now 'Planning Inspectorate' within the Department for Communities and Local Government is responsible for doing so[15].

In the UK, local governments are in two different forms: unitary authorities (or single tier) and two tier authorities; they are responsible for preparing Local Transport Plan (LTP), decision making, implementation of policies regarding all local transport functions in their area. In road transport system, they are responsible to make strategic decision and implement policies with respect to non-strategic roads which comprises 98%[16] of road network (DEFRA, 2012c, Marsden and Rye, 2010). In large metropolitan areas, Integrated Transport Authorities (ITAs[17]) are responsible for developing the Local Transport Plans (LTPs) for public transport provision. More than 95% of the local councils in England have signed up to the Nottingham Declaration which is a voluntary pledge to demonstrate their commitment to climate change adaptation (Boyd et al., 2011).

2.8.2 Scotland

Excluding safety matters, road transport is devolved by the Scotland Parliament. The trunk road and motorway network which comprises 2000 miles (about 6.3% of the whole Scottish road network) are managed and maintained by Transport Scotland. Trunk roads carry 37% of all traffic and 63% of all heavy goods vehicles (Scotland, 2011).

[15] See http://www.planningportal.gov.uk/planning/planninginspectorate
[16] The Highways Agency assert that is responsible for trunk roads that is near 4% of all roads
[17] Formerly Passenger Transport Authorities (PTAs), Local Transport Act 2008 renamed PTA to ITA.

Considering the National Planning Framework (2004) as the main Scotland-wide vehicle for setting transport priorities and integrated land use planning, Scottish-Executive published the '*Scotland's National Transport Strategy*' (NTS) in 2006 and proposed overall national policy goals and a range of measures to be achieved at the regional and local levels. Transport Scotland has a significant role regarding the operation and maintenance of trunk roads, rail and major public transport projects. It is the Scottish Government's duty to monitor the progress of NTS every four year using a set of indicators. Funding for the implementation of the NTS is coming from both public and private sectors (Scottish-Executive, 2006). However, according to Docherty and Shaw (2003), the Scottish Executive provides funding for the majority of Scotland's transport system including road, rail, air and water transport in relation with different issues (safety, operation and infrastructure).

In order to deliver the Scottish Governments' vision on the adaptation of the transport sector to climate change, Transport Scotland has published some guidance and reports such as "Scottish Road Network Landslides Study Implementation Report"[18], "Scottish Road Network Climate Change Study"[19] and "High Wind Strategy and National Wind Management Guidelines"[20].

In Scotland, Local Governments are accountable to their electorates and are responsible for the provision of public services such as planning, social care, waste management, education and cultural services. Their areas vary in size and population for example from 26 square miles in Dundee to 12,437 square miles in the Highlands, and 20,000 people in the Orkney Islands to over 600,000 people in the Glasgow City[21]. In transport sector, 32 elected local authorities (unitary) in Scotland are responsible for the remained 93.7% of the Scottish local road networks. They are responsible for planning, maintaining and implementing local road projects (non-trunk roads). Convention of Scottish Local Authorities (COSLA)

[18] See http://www.transportscotland.gov.uk/files/documents/reports/j10107/j10107.pdf
[19] See http://www.scotland.gov.uk/Publications/2005/07/08131510/15117
[20] See http://www.transportscotland.gov.uk/files/documents/reports/j10783/j10783.pdf
[21] See http://www.scotland.gov.uk/Topics/Government/local-government/localg

with members from councils is the cooperating body between the local governments and central government. The local governments in Scotland do not have a major role in providing of bus public transport as the majority of bus services are operated by private bus companies. However, local governments can allocate subsidies for required services in their areas.

Scottish Government guides local governments by publishing the Scottish Planning Policies (SPPs) and National Planning Framework (NPF). Recently published "Scottish Planning Policy" supersedes some of the previous PPSs including the SPP 17 which is Planning for Transport (Scotland, 2010). In 2007, all of the Scotland's local governments joined the 'Scotland's Climate Change Declaration' (SCCD), and now they are committed not only to mitigate climate change by reducing GHG emissions but also to adapt to unavoidable impacts of climate change through working in partnership with their communities[22]. They are also committed to report their progress annually. Analysis of 32 local governments' progress on adaptation in 2011 shows that (SCCD, 2012):

(1) Beside local climate change impacts, variations in availability of resources and expertise, awareness, attitude toward risks and uncertainty were other reasons in variation in the extent and range of works to adapt to climate change.
(2) The number and range of adaptation works have been increased to comparison to 2009 reports.
(3) Most local authorities are in the start point towards adapting to climate change, and the main focus of them in relation with climate change impacts is on flooding.
(4) Most local authorities have considered the land use planning as part of their strategies toward adaptation.

[22] See http://climatechange.sustainable-scotland.net/index.asp

(5) Most of the local authorities have not reported anything about their progress in adapting the transport sector to climate change.

Another tier within the Scotland transport governance model is Regional Transport Partnership (RTP). Under the Transport (Scotland) Act 2005, these partnerships were established by minimum two and maximum five councillors (Parliament, 2005). There are seven statuary RTPs in Scotland[23]. According to Transport-Scotland, the role of RTPs is "to strengthen the planning and delivery of regional transport developments" (Headicar, 2009). According to Marsden and Rye (2010), these bodies are responsible to prepare five year transport strategies (RTS: Regional Transport Strategy) for their regions by taking into account the guidelines of the Scottish Executive.

Marsden and Rye argue that, after Transport (Scotland) Act 2005, RTPs were intended to gain more proportion of local authorities' funds by introducing a more regional dimension to the transport planning in Scotland. However, the Scottish National Party (SNP) "*has reversed this policy and left the RTPs somewhat emasculated and largely dependent on their local authority members for funds*" (Marsden and Rye, 2010, p.675).

2.8.3 Northern Ireland

This section summarises road transport governance structures in Northern Ireland. However, it is crucial to highlight that there were two major changes in Northern Ireland's central and local government structures. At the central government level, in May 2016, re-organisation of central government in Northern Ireland reduced the number of Northern Ireland government departments from 12 to nine. At the local administration level, the number of NI local councils are reduced from 26 to 11 under the Local Government Reform in Northern Ireland.

[23] See http://www.transportscotland.gov.uk/strategy/Regional-Transport-Partnerships

Effective from April 2015, local councils in Northern Ireland Have received new powers and responsibilities related to different functions which were previously delivered by Northern Ireland Executive departments including: local planning functions, off-street parking and local economic development.

NI-Direct (2016) provides a summary of main changes in NI departments' responsibilities from May 2016. NI-Direct (2017) summarises the main changes in power and responsibility distribution in local councils from April 2015. Since, these re-organisations in Northern Ireland, and consequently in Belfast case study area (See 3.4 for case study selection), took place after collecting data for this research, this thesis uses the old names and organisational structure with respect to government departments in Northern Ireland.

Compared with England, Scotland and Wales, Northern Ireland has more control over its transport and also has a more central transport governance model since the transport planning power is centralised in Department for Regional Development (DRD or DRDNI [24]). The only exception is related to the safety issues which are governed by Department for the Environment (DOE [25]).

DRD is the main actor in the transport governance network in Northern Ireland. In the context of road transport, DRD is responsible for (DRDNI, 2012b):

- regional strategic planning and development policy,
- transport strategy and sustainable transport policy
- provision and maintenance of all public roads, and
- public transport policy and performance.

[24] After May 2016, Department for Infrastructure (DfI)

[25] Department of Environment (DOE) was abolished in May 2016. Its environmental responsibilities are passed to Department of Agriculture, Environment & Rural Affairs (DAERA) and its road safety and road safety & Driver and Vehicle Agency (DVA) functions are passed to DfI.

There are two core groups within DRD whose responsibilities are related to road transport. The first division is the "Transport, Policy, Strategy and Legislation"[26] (TPSLD) which is responsible for the development and implementation of the Regional Transport Strategy (RTs) and Regional Development Strategy (RDS)[27]. The second division is the Transport NI (formerly Roads Service) which is the executive agency of the DRD, and is responsible for the maintenance of the roads, bridges, footways, street lighting and car parks in Northern Ireland. The Transport NI has four divisional offices in Belfast, Coleraine, Craigavon and Omagh. Each division then is divided into a number of sections which correspond to district council areas.

The main aim of TPSLD is to integrate the land use and transportation planning. The Regional Planning unit of TPSLD is responsible for Regional Development Strategy (RDS). The latest RDS was published in 2012. The "*Regional Development Strategy (RDS) 2035: Building a Better Future*" has highlighted the importance of climate change in terms of mitigation and adaptation in the transport sector (DRDNI, 2012a).

> *"It is important that we in Northern Ireland plan for the impacts which climate change brings." (DRDNI, 2012a, Foreword by Danny Kennedy, MLA - Minister for Regional Development)*

> "*RG9 Reduce our carbon footprint and facilitate mitigation and adaptation to climate change whilst improving air quality*"

Under the provisions of the Strategic Planning (Northern Ireland) Order 1999, DRD, in consultation with Northern Ireland Departments, is responsible for

---

[26] After May 2016, Transport Strategy Division

[27] A new division, "Public Transport Division", which is responsible for departments' public transport service, integrated transport and accessible transport, is established after May 2016. https://www.drdni.gov.uk/about-drd-governance-policy-and-resources [Accessed 18 October 2015]

formulating and implementation of the RDS. DRD also provides policy guidance and advice in relation to the strategy and its implementation (Legislation, 1999, see Part 3). Northern Ireland Assembly's Committee for Regional Development assists, advices and controls the work of the Minister for Regional Development. The delivery mechanism of the first RDS had sought to balance the view of this committee, and to introduce an effective sub-regional arrangement by taking into account the views of the key stakeholders. In order to ensure and manage the progress in implementing the RDS, an inter-departmental steering group of senior officials was established. This group oversee the implementation of the Strategy, and based on the assessment of this group, the Minister of Regional Development reports the progress of implementation of RDS to Assembly Committee annually.

All departments (and local governments[28]) must take into consideration the RDS as a key document within the planning system in developing their plans and policy statements. Hence, policy documents must be "in general conformity with" the RDS, and the DOE checks the general conformity of the plans.

The DRD monitors and evaluates the progress of implementation of the Strategy and reports them to the Executive annually. Based on the report (of every three years), the DRD analyses the progress in order to ensure that the progress is concerted with the Programme for Government (PfG, 2012) and Investment Strategy for Northern Ireland (ISNI, 2011).

According to Investment Delivery Plan (IDP) for roads, NI-Executive is the main body in funding road projects. Although Irish Government have provided £400m between 2012 and 2014, NI-Executive are providing 87% of the required funding for the construction of road projects between 2008 and 2018 (DRDNI, 2008).

[28] Under the Planning Act (Northern Ireland) 2011, the planning power will transfer to councils once decided by Northern Ireland Assembly.

Regional Transport Strategy (RTS) was published in 2002 and introduced a Strategic Framework for the future planning, funding and delivery of transport policies to achieve the defined aims in RDS. This strategy defined three high level aims: supporting the economy, enhancing the quality of life and reducing the environmental impacts of transport. Although this strategy has not explicitly addressed climate change adaptation, it has mentioned to 'better maintain transport infrastructure' as one of the objectives to achieve the first aim (economic growth). The implementation of RTS is through three transport plan; RSTN[29], BMA[30] and Sub-Region. DRD have the responsibility to monitor the progress of implementation of RTS and Strategic Performance Indicators. Also DRD reviews the Strategy to ensure that the Strategy is aligned with the Executive's aims and objectives (DRDNI, 2002).

Belfast Metropolitan Transport Plan was published by DRD in 2004 and is the realistic local transport plan for BMA up to 2015 (DRDNI, 2004). This Plan has defined four objectives and nine indicators to achieve the aims of RTS: environment, safety, economy and accessibility. Within the environment category, this Plan aims to reduce Nitrogen Oxides and Carbon dioxide by 52% and 20%, respectively. These indicators are used to monitor the implementation of the Plan. DRD has predicted to review this plan according to the economic, social, legal and political environment at five-yearly intervals when necessitate.

Under the section 47 of the Transport Act (Northern Ireland) 1967, the Northern Ireland Transport Holding Company (NITHC) was established (Parliament, 1967). NITHC is a public corporation which works with the public owned bus (Ulsterbus, Goldline and Metro) and rail (Northern Ireland Railways or NIRailways) companies under the Translink brand in Northern Ireland. NITHC is responsible for managing the provision of public transport in Northern Ireland. The board of

[29] - Regional Strategic Transport Network
[30] - Belfast Metropolitan Area

the NITHC are accountable to DRD for delivering public transport services. The chair and the members of the NITHC are appointed by the government for a renewable term of 3 years. The Transport Act (Northern Ireland) Act 1967 gives the power to NIRailways to construct a new railway and to carry out any work for the improvement of the existing railway. After being authorised by DRD, NIRailways is responsible for constructing bridges and tunnels as part of the new or current railway projects and DRD[31] is responsible for funding these projects.

At the local level, Northern Ireland is divided to 26 single-tier district councils[32]. These areas vary in population from Moyle with a population of some 15,000 to Belfast City with a population of around 300,000. Cullingworth and Nadin (2002) argue that local councils in Northern Ireland are consulted only on the preparation of plans and development control matters and don't have a direct responsibility in formulation and implementation of transport polices. The duties of the local governments in Northern Ireland, as an elected tier of governance, are limited to recreation, waste management, tourism, the enforcement of building regulations and miscellaneous licences. But they can reflect the view of the people in their area by giving advices to the government in some issues such as planning, roads, water and conservation (DOENI, 2012c).

Located in the DOE, Local Government Policy Division is responsible for paying general grants to the councils, and providing legislative frameworks to allow councils to perform local public service[33]. Docherty and Shaw (2008) argue that the effectiveness of the transport governance arrangement in Northern Ireland is mainly depended on the cooperation between central government departments.

According to the "*Programme for Government 2011-15: building a better future*", NI-Executive will reduce the number of local councils to 11 by 2015 (NI-Executive,

[31] Public Transport Financial Services and Delivery Division
[32] Reduced to 11, after April 2015. See https://www.nidirect.gov.uk/articles/local-councils
[33] http://www.doeni.gov.uk/index/local_government.htm

2011). Simultaneously new governance arrangements for councils are introduced and some functions are transferred from central to the local governments including planning (from DOE) and 'Public realm functions of local roads' (from DRD) (NI-Assembly, 2012).

2.8.4 Wales

The Welsh Government is the main actor in the Welsh transport governance model. Until 2011, the Welsh Assembly could not determine primary 'domestic' land transport policies. Because of its lack of primary legislative competence, the Welsh Assembly had a limited power over transport sector (Shaw et al., 2009). The policies made in the Welsh Assembly had to be consistent with the UK's policies and it was duty of the relevant secretary of state in the UK to judge about this compliance (Shaw et al., 2009). In March 2011, following a referendum on extending the law-making powers of the National Assembly of Wales, the Welsh Assembly gained the power to make primary decision about the 20 Fields identified in the Government of Wales Act 2006 including economic development, environment, highways and transport, local government, National Assembly for Wales, social welfare and water and flood defence (Parliament, 2006, see schedule 5 and also p.121 for exceptions).

In road transport the Welsh Government is responsible for[34]:

- *constructing new roads and improving existing ones*
- *renewing roads, bridges and other structures*
- *the day to day maintenance, including winter maintenance*
- safeguard the environment during the construction of transport projects

There are also two (North & Mid Wales and south Wales) trunk road agencies in Wales that are responsible for trunk road management and maintenance on behalf

[34] See http://wales.gov.uk/topics/transport/roads/?lang=en

of the Assembly, and work in partnership with their corresponding local authorities. After identifying the needs to be addressed, proposals are submitted to Welsh Assembly Government (WAG) and funding then is allocated.

Under the section 5 of the Transport (Wales) Act 2006 the Welsh Assembly gained the power to establish Joint Transport Authorities (JTAs) to control the delivery of the national transport policies at the regional and local levels. Welsh Assembly is responsible for financing JTAs and the local governments to discharge their functions related to transport. Despite having six areas, Wales has four voluntary Regional Transport Consortia (RTCs): Sewta (10 LAs), SWWITCH (4 LAs), Taith (6 LAs) and TraCC (3 LAs) (Stafford, 2010)[35]. Each consortium has its own regional plan and all of them have introduced climate change mitigation and adaptation to their regional transport and delivery plans (Taith, 2009, TraCC, 2008, Sewta, 2010, SWWITCH, n.d.). RTCs are committed to develop their plans in consistent with the objectives defined by the Welsh Transport Strategy (Wales, 2008a) and Welsh Transport Planning and Appraisal Guidance (WelTAG) (Wales, 2008b).

Accounting for £5 billion of the Welsh Government budget, 22 unitary local governments are the major service provider in Wales. In order to strengthen the delivery of government's aims and support authorities to deliver "excellent" local service, the Welsh Assembly Government has adopted a partnership approach to work with the local governments. By adopting the '*Local Government Partnership Scheme 2008*' the Welsh Government became committed to consider the viewpoint of the local government in all aspects of its work. This partnership approach also committed the Welsh Ministers to take into consideration any advice which has been given by the Partnership Council for Wales[36] (Welsh-Assembly, 2008).

[35] Gwynedd has been mentioned in list of both Taith and TraCC.
[36] See http://wales.gov.uk/topics/localgovernment/partnership/council/?lang=en for more details about Partnership Council for Wales

The 'Welsh Local Government Association (WLGA)' is a partnership between all of the local authorities. The main purposes of WLGA are to "*promote better local government and its reputation and to support authorities in the development of policies and priorities which will improve public services and democracy*" (WLGA, 2012).

2.9 Summary: Governance of Climate Change Adaptation

The most important theories of policy implementation within the two broad categories of top-down and bottom-up approach, and the main barriers for the implementation of climate change adaptation policies at the local level were discussed in Section 2.5 and Section 2.6, respectively. This section begins with an assessment of the linkage between the proposed policy implementation theories and findings of the empirical studies about the main challenges and opportunities for effective implementation of the climate change adaptation policies. To do so, it highlights why none of the policy implementation approaches, i.e. top-down (see Section 2.5.1) or bottom-up (see Section 2.5.3) solely can be an effective solution in tackling the impacts of climate change. Explaining the concept of governance and good governance, this section then continues with an assessment of the suitability of synthesised theories of policy implementation to guide this study in finding a better design in empirical phase of the research. This section ends with the review of the main themes surrounding the governance of climate change adaptation.

As discussed in Section 2.5.4, given the influence of a variety of factors originated from different levels of the governance, none of the both top-down or bottom-up approaches are able to model the reality of the process of the policy implementation. This justification is completely correct in the case of the implementation of climate change adaptation policies. As discussed in Section 2.6, barriers to the effective implementation of adaptation policies cannot be categorised in a single top-down or bottom-up model. The emphasis of the top-down approach on clear policies and responsibilities is required, but is not sufficient as this approach cannot justify a variety of variables which impede the adaptation at the local level. As discussed in section 2.6.1 and Section 2.6.4, uncertainty about the impacts of climate change, the long term nature of the adaptation measures (regarding the return of investment) and its conflict with the short-term electoral cycles persuade local politicians to focus on the policy areas which are cost-effective in the short-term. In addition, the main motivator for local politicians in implementing climate change adaptation policies is the demand of public residuals. This demand in turn is affected by attitudes of national politicians. Hence, concluding that the process of climate change adaptation can be modelled by employing a top-down approach is very far from reality.

On the other hand, the bottom-up approach is also not able to explain the whole process of climate change adaptation including the initiation of the policy at the national level and translating this policy into local initiatives and actions. As discussed in Section 2.6, tackling the impacts of climate change at the local level requires a scientific and economic support from higher levels of the governance. Considering the barriers of local actors in dealing with climate change such as a lack of expertise and limited financial resource, it can be asserted that the unpredictable impacts of climate change can be better assessed and addressed through providing them with clear guidelines and information from the higher levels of governance. Hence, it can be concluded that the bottom-up approach is also unable to explain all variables of successful implementation of climate change adaptation policies.

Therefore, a combination of a top-down and bottom-up approaches should be considered. As discussed in section 2.5.4, policy analysts have developed a number of synthesised theoretical frameworks to assess the process of policy implementation. Although, these frameworks have been widely employed in the previous research to investigate the factors affecting the success or failure of a policy but there are a number of reasons suggesting that this group of theories are not also a suitable base for the purpose of this research. As discussed in Chapter 1, the research about climate change adaptation remains in its infancy. Most of the literature in the context of climate change are related to climate change mitigation and carbon reduction. Moreover, there is not considerable research which investigates the process of climate change adaptation in transport sector. Given that policy implementation is a context dependant field of research, it can be concluded that choosing a theoretical framework perhaps can limit the scope of the research. The literature suggests that by increasing the number of studies in the field of climate change adaptation over the time many new factors have been found. For example, reviewing the literature about the multi-level governance of climate change adaptation, Corfee-Morlot et al. (2011) argue that there are 13 variables that impede the process of climate change adaptation. However, a recent study in Australia indicates that there are 50 variables which affect the process of adaptation (Waters et al., 2014). According to Hill and Hupe (2002), different policy contexts need to be analysed with different approaches. Elmore (1979) indicates that each model and framework is a simplification of the reality, and given the complex process of the policy implementation, it is not possible to have a model which suits to all contexts. It can be concluded that instead of choosing a specific theoretical approach and restricting the scope of the research about the process of climate change adaptation, it is beneficial to consider these frameworks and their categorisation of variables as the start point of the empirical research. In other words, this thesis does not limit this research to the variables discussed in the policy implementation literature. Acknowledging these frameworks and their variables; this thesis aims to develop a methodological framework which provides maximum opportunities for finding variables of effective implementation of climate change adaptation policies in transport sector (Chapter 3).

Although, the developers of theoretical frameworks are using the findings of empirical studies for improving their models and frameworks (Sabatier, 2007), but in recent years, the focus of the policy implementation literature has been changed from choosing a theoretical framework as the benchmark to employing a conceptual framework such as governance (Craft et al., 2013, Schmidt et al., 2013), multi-level governance (Bache et al., 2015a, Nilsson et al., 2012, Marsden and Rye, 2010) or good governance (Legacy et al., 2012, Hill, 2013). Employing these conceptual frameworks enable the researcher not to limit their research to the predefined variables of the theoretical frameworks and allow them to explore a new set of variables which are more compliant with the context of the study.

> “The concept of "governance" is not new. It is as old as human civilization. Simply put "governance" means: the process of decision-making and the process by which decisions are implemented (or not implemented)”.
>
> (UNESCAP, 2011, p.1)

However, the popularity of governance concept in recent decades is indeed due to the lengthy debate between two opposite approaches, namely top-down and bottom-up (Hill and Hupe, 2002). This perspective argues that neither pure top-down nor bottom-up approaches can explain the exact process of policy implementation in the real world. In addition, none of these perspectives can solely lead to success in delivery of policy on the ground (Urwin and Jordan, 2008, Walker et al., 2014). It can be concluded that ‘good governance’ is about mixing these pure perspectives by giving the optimum level of power, responsibility and resource to each of the actors involved at different levels of the process (including designing a governing mechanism) to facilitate the planning and delivery of the programme.

A huge amount of literature on the issue of governance has been produced in recent decades looking for the different dimensions and themes that can navigate the system's current modes of governing to a good governance mode. The United Nation's conceptual framework has mentioned eight characteristics for good governance namely accountable, transparent, responsive, equitable and inclusive, effective and efficient, follow the rule of the law, participatory and consensus oriented. "Good governance assures that corruption is minimised, the views of minorities are taken into account and that the voices of the most vulnerable in society are heard in decision-making" (UNESCAP, 2011, p.1). The remaining of this section discusses the main themes around the governance of climate change adaptation.

A high degree of the coordination between national and local planning parties is necessary to implement the adaptation policies quickly and effectively. According to Tanner et al. (2009) although the top-down decision making structure in some case studies is the main reason for the quick implementation of adaptation policies, and also decentralised decision making may create conflicts between the different agencies in the implementation chain, but a high level of coordination between different actors in different phases of policy process allows the local actors, both formal and informal, to better understand, participate and influence the adaptation programme. In addition, higher level (national) actors will also have a good opportunity to obtain the local level risks to integrate with the future risk assessments and guidelines. Consequently this dialogue helps cities increase their resilience against climate change by increasing the transparency of the process (Harrison et al., 2013).

The literature reveals the important role of transparency in effective decision making through promoting "dialogue between the research and stakeholder communities within a process of mutual learning and guidance" (Harrison et al., 2013, p.762). An urban area with an administrative system that supports the right to have access to the required information has more potential to investigate climate change and its potential impacts in the future. Transparency in the information will give the researchers more confidence and chance to find the solutions to the increased risks of climate change and they will push the administrative leaders to improve the policies in order to respond better to climate change impacts (Tanner et al., 2009).

Learning and flexibility are also required factors for a system to be resilient. As a result of the high uncertainty of climate change impacts, it would not be surprising if in the near future new kinds of climate change impacts (which were not experienced previously at a specific local area) or more severe and greater frequency of previous impacts emerge (Tanner et al., 2009). A regular review of adaptation policy and framework is necessary to ensure they work appropriately and are flexible for new situations (Celliers et al., 2013). A flexible governance system can easily reflect the new circumstances (Pelling and High, 2005). Tanner et al. (2009, p.4) states that "highly knowledgeable officials, able to draw on the experiences of other cities, able to network across agencies, able to learn from the disaster management and response community and able to integrate the work of climate scientists all help to promote the necessary flexibility". In other words, as Mazmanian et al. (2013, p.15) states "planning for adaptation should itself be adaptive". Involving the full participation of local communities, strong approaches to risk assessment and suitable funding resource are the most important factors of an adaptive governance (Schmidt et al., 2013). In addition, officials need more knowledge and information to integrate the findings of scientists and climate change scenarios into their planning and designs to update measures that have not been taken into account by them previously. Using the experience of other cities in responding to impacts can help promote the knowledge of officials and consequently this will lead to the flexibility (Wilby and Dessai, 2010).

Another important aspect of good governance is participation and inclusion (van Aalst et al., 2008). The views of vulnerable groups about climate change impacts should be considered in decision making about the adaptation process as they have seen the problems from close distance, hence they can help in finding better solutions (Celliers et al., 2013). However, if decision makers do not pay sufficient attention to their attitudes in decision making process, they might miss some of the main dimensions. According to Fatti and Patel (2013) good governance at the local level is not only about making connections with the society, it is also about making synergy between local, provincial and national level interventions. Table 2-4 summarises this section and highlights the main questions need to be addressed in empirical phase of this research.

Table 2-4: questions for empirical phase of study

Main themes	Questions
Transport sector and climate change challenge	• What are the key climate change challenges in road transport sector? • What are the possible measures for adaptation? • What are the main barriers in decision making and implementation of climate change adaptation policies?
Adequacy of policy measures	• What policies are currently in place which support climate change adaptation in transport sector? • How effective are these policies? • What other policy measures should be considered? • How should climate change adaptation policies be prioritised?
Governance	• Who are the key stakeholders involved in translating climate change adaptation objectives into local transport initiatives and actions? • How do different stakeholders manage their working relationships? • How effective are the existing transport governance arrangements in the implementation and delivery of transport policies and proposals? • What changes are required in power distribution between different actors to improve the delivery of climate change adaptation policies?

Transparency, accountability and participation	• How do interest groups involve/impact the process of policy implementation • How do the transport organisations respond to potential climate change impacts? (capacity/knowledge on climate change/uncertainty/ climate change scenarios) • Is the current transport governance model accountable? What changes are needed? • Is the policy implementation process transparent? What changes are needed?
Funding mechanism	• What are the primary funding sources for transport projects? • Are there enough investments in road transport sector to adapt to climate change impacts? Should more financial incentives be made available? • How important is the role of politicians in the prioritisation of transport projects? • Does the funding regime help road transport sector to adapt to climate change? What changes are needed?

Chapter 3 - Research Methodology

3.1 Introduction

This chapter discusses the methods that are used for collecting and analysing data during the empirical research. As discussed in Chapters 1 and 2, adapting the transport sector to the impacts of the climate change involves a variety of actors during policy initiation, policy formulation and policy implementation to transfer the national policies to local actions. This means that climate change adaptation is a complex process as different actors have different attitudes toward this problem and the potential solutions. As mentioned in Chapter 1, the aim of this research is to investigate the relationship between different transport governance arrangements and the implementation of climate change adaptation policies at the city level. This chapter starts with the review of the methods that have been used by previous researchers in section 3.2. In section 3.3, considering the research questions developed in Chapter 1, it then proposes the most suitable research design for this study and justifies why using a mixed method approach (combination of qualitative and quantitative approach) is more beneficial to answer those research questions. Section 3.3 and section 3.4 discuss the advantages of using a multiple case study method and justify the selection of the case study areas, respectively. Section 3.6 and section 3.8 concentrate on the methods of the collection and analysis of the qualitative and quantitative data, respectively. Section 3.9 details the process of the data analysis for the Q methodology. Section 3.10 reviews and analyses 36 peer-reviewed Q studies. Section 3.11 and section 3.12 simulate the process of the Q methodology aiming at finding a suitable sample size and sorting sheet for the purpose of this study. And finally 3.14 summarises the findings of this chapter.

3.2 Methods Used in Previous Studies

Although increasing in recent years, research on the climate change adaptation policies at the city level is still in its infancy and globally scholars have focused on initiating mitigation policies to address climate change (Kern and Alber, 2008, Dannevig et al., 2012). A review of recently published literature shows that researchers have used a variety of methods to analyse the process of climate change adaptation policies. The most common methods used by previous researchers for collecting empirical data are case study approach combined with semi-structured interview and focus group discussion. This section summarises the methods and techniques used by previous researchers for empirically analysing the process of implementation of climate change adaptation policies at local levels.

Urwin and Jordan (2008) examined the influence of 'non-climate' policy on the capacity of local organisations to adapt to climate change across three sectors (water resources, agriculture and nature conversation). Drawing on a case study in the UK, this study has employed a combination of top-down and bottom-up approaches. The first one utilises content analysis of policy documents and legislation, whereas the latter is based on interviews with individuals from key organisations in each sector. Interviews are conducted in three parts that include both semi-structured and structured questions. For Urwin and Jordan, adaptation is a process of learning. Semi-structured interview with policy makers, supported by content analysis of official documentation, was conducted to understand how organisations are learning about the climate change. Quantitative data were gained through structured interview with actors involved in different organisations. Finally, by triangulation of the results from these methods, Urwin and Jordan found the potential opportunities to enhance the adaptive capacity at both national and local (organisational) level.

Smith et al. (2009) have used a range of methods to analyse the adaptive capacity of local governments in Australia. Their methodology integrates both top-down and bottom-up analytical approaches to answer the questions about the complexity of process by which climate change policy decisions are made. 15 stakeholder workshops were conducted to obtain three criteria for case study selection. Three cases for further studies were selected and 10-12 interviews were conducted in each case (totally 33). Semi-structured interviews with council staff and elected representatives was the main source of data for the study. Content analysis of official documents was also used to identify the formal responsibilities of councils regarding climate change adaptation.

By using a case study approach, Biesbroek et al. (2010) analysed and compared the National Adaptation Strategies (NAS) of seven EU member countries. Several criteria were established to select countries. Access to primary data source was one of the most important criteria in case study selection. Policy document analysis was used as the main strategy for gathering primary data. This analysis was complemented by 32 semi-structured interviews with government representatives that had an active role in developing and/or implementing the adaptation strategy.

Warden (2011) describes some of the factors that led to American cities committing to address climate change and discusses the role of international networks (ICLEI and C40) on engagement of cities worldwide on climate change issues. The first stage of Warden's research includes a literature review and content analysis of official documents. Findings of this stage were complemented by in-depth, semi-structured interviews conducted with key informants from nine cities, which were selected as case study.

Based on case studies in urban regions of five European countries, Grothmann (2011) has conducted an expert survey (252 experts) on the guiding principles for adaptation to climate change. As a first step, a set of 12 guiding principles for adaptation was developed by synthesising about 100 different sources of literature on designing, implementing and evaluating adaptation to climate change. In the second step, these principles were evaluated in an online survey by adaptation experts with practical experience and/or planning responsibility in the field. Survey participants came from local, regional and European decision making levels, and included representatives of governments, NGOs, research institutes and business organisations in different climate sensitive sectors.

Heinrichs and Krellenberg (2011) characterise the adaptation efforts of the two cases (São Paulo and Santiago) based on local climate conditions with respect to actors, priorities and approaches. Drawing upon a literature review, analysis of statistical data, a review of official documents and expert interviews, this study finds particular implementation challenges associated with climate change adaptation at the city level.

Vrolijks et al. (2011) review and analyse the climate plans of ten cities. This study examines how each city perceives its hazard profile and reviews how the different aspects of climate change impacts at the city level are being addressed in climate plans. Amundsen et al. (2010) conducted two national surveys to assess the adaptation measures taken by local governments in Norway. Drawing on case study research in two Canadian cities, Henstra (2012) examines elements of urban climate adaptation policy and analyses the policy development process. Table 3-1 summarises the methods used in previous studies.

According to Hunt and Watkiss (2011, p.442), quantitative methods receives only limited coverage in the climate change adaptation literature and the "majority of studies undertaken to date are qualitative in nature". The literature review confirms that the most common approach used by previous researchers for collecting empirical data are case study method, semi-structured interview and focus group discussion.

Table 3-1: Summary of methods used in the previous studies

Description	Reference	Case Study	Interview/ Workshop/ Group meeting	Questionnaire	Document Analysis and L.R.	Other
To explore the role of sub-elements of policies in supporting or undermining adaptive responses	(Urwin and Jordan, 2008)	☑	☑		☑	

Description	Reference	Case Study	Interview/ Workshop/ Group meeting	Questionnaire	Document Analysis and L.R.	Other
To assess the ability of cities to plan and implement an integrated climate resilience programme	(Tanner et al., 2009)	☑	☑		☑	
To analyse the adaptive capacity of local governments in Australia	(Smith et al., 2009)	☑	☑		☑	
To review how different aspects of climatic impacts are being addressed in city climate plans	(Vrolijks et al., 2011)	☑			☑	
To assess characteristics of adaptation efforts and to explore and analyse implementation challenges for the long-tern risks of climate change at the local level	(Heinrichs and Krellenberg, 2011)	☑	☑		☑	analysis of statistical data
Social barriers to climate change adaptation at the local level	(Grothmann, 2011)	☑	☑	☑	☑	
To investigate viral governance and mixed motivation of U.S. cities on the climate change issue	(Warden, 2011)	☑	☑		☑	
To examine elements of climate adaptation policies and to analyse the policy development process targeting extreme weather in two Canadian provinces	(Henstra, 2012)	☑			☑	
To examine the process of initiation and development of adaptation planning at city level	(Carmin et al., 2012)	☑	☑		☑	
Knowledge for local climate change adaptation in Sweden: challenges of multilevel governance	(Nilsson et al., 2012)	☑	☑		☑	
To examine the integration of climate change adaptation policies at the local level with emphasis on the role of a municipality's size, risk and experience	(Berg and Coenen, 2012)	☑	☑		☑	
To investigate the role of governance modes on planning and implementation of adaptation policies at the local level	(Lund et al., 2012)	☑	☑	☑	☑	
To investigate how and why climate change adaptation measures are adopted and implemented at the local level	(Dannevig et al., 2012)	☑	☑	☑	☑	
To examine the adaptation barriers by reviewing the national and local policies with emphasis on the role of 'visionary	(Langlais, 2009)	☑	☑		☑	

Description	Reference	Case Study	Interview/ Workshop/ Group meeting	Questionnaire	Document Analysis and L.R.	Other
individuals'						
Planning and governance of climate change in the UK	(Bulkeley, 2009)				☑	
To examine the current state of urban climate change policy and action	(Bulkeley et al., 2011)	☑			☑	

3.3 Case Study Approach

Yin (2009, p.18) defined the case study research method as "an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used".

Case study method has some advantages specified it as a distinguished research method. According to Zainal (2007), the quantitative methods have some limitation to provide holistic explanations of the behavioral and social problems. Case study method is such an approach that can be used to overcome the limitations that quantitative methods have faced with them. This method enables researchers to go beyond the quantitative methods that mostly aim to describe or explain an event. This method helps describe both the procedure and consequence of a phenomenon via the complete observation, reconstruction and analysis of cases under investigation. (Zainal, 2007). The complexity of the policy implementation process means that quantitative methods on their own are unlikely to obtain adequate in depth data to answer the research questions. Hence, case study approach can be used to explore and understand complex issues and can play a prominent role in the in-depth investigation of this complex issue. (Zainal, 2007).

Yin (2009, p.27) has identified five component of a case study research design as below:

(1) Research questions: the nature of research questions is very important in designing a research. As Yin has pointed out case study research is most likely to be appropriate for "how" and "why" questions. According to the aim of this study (see section 1.2), we seeks to answer to "how" are national climate change adaptation policies being adopted, designed and implemented within the transport governance system? And "how" could the process of decision making and policy implementation be improved at the local level?

(2) Its propositions: "each proposition directs attention to something that should be examined within the scope of study" (ibid, p.28).

In this study, we define two propositions as follows:

- (P1) The extent to which local level decision makers have initiated and implemented the national climate change adaptation policies is depend on different factors, both internal and external to the organisations.

- (P2) Stakeholders in different transport governance models have experienced different challenges in their organisations.

(3) Units of study

Defining the unit of analysis has been mentioned as the most important issue in the case study design by Yin (1993, p.10). He mentioned the following reasons for the importance of unit of study:

a) Defining the unit allow the researchers to limit the boundaries of the study: Because the case study research permit researchers to collect data from many perspectives and from different time periods, it is necessary to limit the boundaries by clearly defining the unit of study.

b) Generalisation: the finding of a case study research with a clearly defined unit of analysis can be generalised. This means a case study can be generalised to a similar case focusing on the same unit of analysis.

In this study the unit of analysis and comparison is selected as local. This selection can be justified by assuming that the clearest difference between the outcomes from different governance structures (different level of implementation at the local level) can be seen at this level.

(4) the logic linking the data to the propositions; and

(5) the criteria for interpreting the findings

Design of case studies can be single-case study design or multiple-case study design. In some cases that there is no access to the other cases or in single occurrence events, a single-case design can be used. The main disadvantage of using a single-case design is its weakness to present a generalised conclusion. This study will employ the multiple-case study design. According to Zainal (2007), the multiple-case design can be used in the studying of real-life events when there are numerous sources of evidence via replication. Multiple-case design can be used in order to enhance and support the previous results through the replication of the case via a technique known as pattern-matching which links the information obtained from the same case to the theoretical proposition. This characteristic of a multi-case design makes it more reliable (Yin, 2009, Zainal, 2007).

3.4 Case Study Selection

Literature review identified factors that are used for selecting the case studies in this research. These factors can be classified in two different categories. The first category (Set A) includes those parameters that will be relatively similar in all of our cases, while Set B category includes those variables which their influences on the outcome of the implementation of climate change adaptation policies are the primary objectives of this research.

Parameters in Set A have had influential role in the process of climate change policy implementation in previous studies, but their roles are not included within the purposes of this study. The first criterion in this set is the impacts of climate change. According to Amundsen et al. (2010), municipalities that have experienced climate change impacts are more active in adapting their areas to climate change than municipalities that have not affected by these impacts. Henstra (2012) asserts that citizens' concern about climate change is the main motivator for placing climate change adaptation on the city policy agenda. According to Simonsson et al. (2011), adaptation to climate change is to a large extent reactive to the existing impacts of climate change at the local level. Therefore, selected case study cities in this study must have experienced relatively similar impacts of climate change.

Another criterion in Set A category is the demographic characteristic of the areas under investigation. A study by Manasfi and Greenhalgh (2011) in the UK shows that the extent to which a municipality must adapt to the impacts of climate change is dependent on the demographic characteristics of that area. According to this research, the climate change adaptation can be of higher priority for larger local governments. This is similar to the finding of a study in Norway. Dannevig et al. (2012, p.597) states that "municipalities are able to implement adaptation policies that are not initiated at the central level, but are contingent upon a number of factors: the efforts of individuals within the municipal organisation, *municipal size*, and the use of external expertise". By considering this criterion, the city of London was excluded from the initial list. This exclusion can also be justified by the fact that the transport governance of the London city is unique and hence is not comparable to other cities in the UK.

A focus on the UK context was maintained due to considering the location of the researcher. It was also decided to include the city of Dublin, in the Republic of Ireland, within the initial case study list. But according to Sabatier's Advocacy Coalition Framework (Sabatier, 1986), external events, including large scale changes in socio-economic conditions, will affect the process of policy implementation. Hence, it can be concluded that the current Irish financial crisis (2008-2012) will have implications for the implementation of climate change policies (Creutzig et al., 2014), as financial resource is one of the most important factor in implementing the adaptation policies and measures (Schmidt et al., 2013). Moreover, recently published Climate Change Risk Assessment (CCRA) has determined the potential impacts of the climate change on transport sector throughout the UK (DEFRA, 2012f). According to the aim of this study, which is examining the role of different transport governance models in implementation of climate change adaptation policies, selection of the case studies in the UK can minimise the influence of perceived climate change risks on the policy implementation process.

Given the aim of this study, which is to examine the relationship between transport governance arrangement and implementation of climate change adaptation policies, the second set of criteria (Set B) for selection of the case studies is the governance arrangement and division of power and responsibility among actors with special attention to the differences in transport governance models in the UK and devolved administrations at the local level. The literature points out that good coordination between actors at different levels, clear policy and legislation framework, existence of and access to information are required to enhance the resilience of urban areas by means of better formulating and implementing the climate change adaptation policies. In addition, lack of mandate to address climate change issues, short term electoral cycles and long time lag to reap full adaptation benefit, lack of access to expertise and funding constraint are other constraints in the process of climate change policy implementation at the local level.

In comparison to other administrations in the UK, Northern Ireland has more control over its transport system and also has more central transport governance as transport planning power is centralised in Department for Regional Development (DRD) and Department for the Environment (DOE). Local governments in Northern Ireland have limited power and play consultant role in transport planning. In contrast, transport governance in England is more decentralised. Local governments in England are in two different forms; unitary authorities (or single tier) and two tier authorities, county council and district councils. Country councils are responsible for development and implementation of the local transport strategy and plans, while district council are responsible for the planning decisions including those plans which are related to the local transport. In Scotland, although Transport Scotland is responsible for rails and trunk roads, 32 unitary local authorities are responsible for 93.7% of the Scottish local road networks. Also Scottish Government has limited control over the provision of public transport as the majority of bus services are operated by private bus companies. However, local governments can allocate subsidy for required services in their areas. Regional Transport Partnerships (RTPs), partnerships among local governments in a region, are responsible to prepare five year transport strategies (RTSs) for their regions and are the main channel for the Scottish-Executive for funding the transport project.

Hence, the comparison between transport governance systems in Northern Ireland, with those arrangement in Scotland or England can provide the researcher with valuable insights into the effects of different transport governance structure on the decision making and implementation of the climate change adaptation policies at the local level. On the other hand, comparison between a single tier system at the local with a two tier system can be beneficial in better understanding the role of horizontal coordination of the bodies responsible for the planning and transport decisions. Based on the above mentioned criteria and by using the UKCP09[37] to understand the potential impacts of climate change in the UK, Belfast in Northern Ireland and Cambridge in England were selected as the case study areas of this research. Table 3-2 justifies the selection of case study areas.

Table 3-2: Justification of case study selection

	Belfast	**Cambridge**
Impacts of climate change (2050-medium)	Winter temperature: +0.6-3.0 °C Summer temperature: +0.9-3.9 °C Winter precipitation:+2%-20% Summer precipitation: -5%-25% Sea level: +11-19 cm	Winter T:+2.6-3.7 °C Summer T:+1.3-4.7 °C Winter P:+16%-26% Summer P: -14%-27%
Impacts	Milder winters Hotter summers Increased Flooding and coastal	Increased summer temperatures and heatwaves. Increases in the amount and

[37] http://ukclimateprojections-ui.defra.gov.uk/ui/admin/login.php

	erosion may pose an increasing threat to people, property, critical infrastructure and important natural habitats. (CCRA for NI, 2012) [flood map]	intensity of rainfall in the winter are predicted to increase the area of severe flood risk in Cambridge City from the River Cam. [flood map] There is a significant risk from flash flooding. Around two-thirds of the flooding resulted from rainfall exceeding the local drainage capacity rather than rivers bursting their banks. (Cambridge City Council, 2012)
GHG Emissions	Share of transport: 23% 12.5 tCO2 e/per person (NI) 2.4 tCO2 e/per person (NI) - transport Transport GHG: +38.8% increase from 1990 to 2011 [DOENI, 2011]	Share of transport: 25% [2013] About 9.5 tCO2 e/per person (England) 2.0 tCO2 e/per person (UK)- transport Transport GHG: -2.4% decrease from 1990 to 2011 [2013]
Climate change related policy documents	Climate Change Risk Assessment (CCRA)-2012 The NI Climate Change adaptation programme-2014	Climate Change Act- 2008 Climate Change Risk Assessment (CCRA)-2012 Highway Agency CC Risk Assessment Regional and local level risk assessments.
Climate change organisations	DOE (Cross Departmental Working Group), Committee on Climate Change	DEFRA, Environment Agency, Committee on Climate Change, Adaptation sub-committee
Transport organisations	NI Assembly, DRD/Translink , DOE	Westminster, DFT, Highways England, East of England Local Government Association
Transport governance model	Centralised system (single authority model) DRD: regional strategic planning, transport strategy, provision and maintenance of roads, and public transport. DOE for safety issues.	Two tier arrangement: County Council: transport strategy and LTPs (Greater Cambridge Local Transport Body) City Council: transport related planning decisions
Local government power and control	Week Local Authorities regarding the transport policy and delivery.	Responsible for preparing general transport strategy, local transport plans, passenger transport and highways; parking and street lighting, and local transport planning decisions. Responsible to report the progress on climate change adaptation.
Public transport	Regulated public transport system	De-regulated public transport system
Population Density	2452 people per sq Km	3015 people per sq Km
Transport infrastructures	Bus/train/road No continues cycle path	More robust cycle path Bus/road infrastructure No train for traveling inside the city (only one central train station)
Car & Bicycle	Average tfw journey length: 9 miles [2010-12] 39% at least one bicycle NI Access to at least one car: 78% of household [2010-12]	Average tfw journey length: 12.8 miles [2013] About 80% access to car (East England) Tops list for cycling in England (at

	Belfast Access to at least one car: 56% of households [2010-12] 75% (17+) holding driving licence [2010-12] Car > Public Transport > Walking/Cycling	least 49% once per week- average England:10%). Although car is dominant (50%), public transport and walking/cycling modes have significant share of journeys. Car> Walking/Cycling > Public Transport

3.5 Research Questions & Research Design

There are two broad methods of reasoning in research; namely inductive and deductive approaches. Deduction, informally called a "top-down" approach, is an approach in which a hypothesis, an initial prediction originated from previous experiments, can be tested and therefore theory will become the end point for study. Inductive research approach works the other way. This approach moves from detailed observation of the world's regular events to broader generalisations and theories and conclusion is likely based on promises and sometimes is called "bottom-up" approach (Burney, 2008).

Unlike physical research that is based on the experimental method and establishes controlled conditions, social research aims to develop theories, find patterns of regularity and clarify facts in social life. In other words, this type of research seeks to define a framework out of the collected data and develop general theories aiming at explaining the regular events (Neuman, 2007). Considering the distinctions between two approaches, inductive research is most appropriate path for this thesis.

One of the differences between deductive and inductive approaches, listed by Saunders et al. (2009), is the data collection method, i.e. qualitative and quantitative. Saunders et al. (2009) argue that although there is no distinction in selection between methods for data collection, inductive and deductive approaches are more compatible with qualitative and quantitative data, respectively. Qualitative approach can provide rich data (detailed and widely applicable) and is less structured, easier to develop, labour intensive to collect and challenging to analyse and usually generates longer reports. On the other hand, quantitative approach is more structured, reliable, easier to analyse and attempts to provide accurate measures (IPDET, 2001). Table 3-3 compares the characteristics of quantitative and qualitative research methodologies.

Table 3-3: Characteristics of Quantitative and Qualitative Approaches

Different dimensions	Quantitative research	Qualitative research
Knowledge investigated	Objective	Subjective
Reasoning	Deductive	Inductive
Question format	Close-ended	Open-ended
Focus	Concise and narrow	Complex and broad
Ability in research	Tests theory	Develops Theory
Basic of knowing	Cause and effect	Discovery, on-going processes
Elements of analysis	Numbers and statistical data (Numerical form)	Words, images, observations and transcripts (Verbal form)
Reliability and validity	Through statistical and logical methods	Through multiple sources of information (triangulation)
Application	Single reality that can be measured and generalised	Multiple realities are continually changing with individual interpretation

Source: (Keele, 2010, Neuman, 2007, Mack et al., 2005)

Decisions regarding the type of design and selection of data collection method mainly depend on the nature of the research questions being asked (Yin, 2009, Frankel and Devers, 2000). Qualitative research approaches are more concerned with the process rather than the outcome and are appropriate approach for answering the questions that take the form of “why?” and “how?”. Answering to some of research questions, such as “What factors do influence on the implementation and integration of climate change adaptation policies into road transport sector policy?”, needs a wide range of data for evaluation of stakeholders’ views about the barriers in the process of implementing the climate change adaptation policies.

Review of the current literature shows that the implementation of climate change adaptation policies is very challenging. In the UK, formulation and implementation of climate change related policies are taking place across multiple spatial levels with large number of actors. Moreover, since the transport sector does not respect administrative boundaries, it is also a challenging policy sector (Marsden and Rye, 2010). Hence, using an exploratory qualitative method will help to cover this wide range of factors and this approach will be used in order to answer this type of questions. In contrast, quantitative method attempts to provide accurate measures and is a proper strategy for examining the relationship between different variables. Table 3-4 shows the defined research questions for this study and identifies the appropriate research design to answering them based on the characteristics of each research question.

Table 3-4: Justification of Research Design

Research questions	Characteristics of question	Design
What are differences between both 'climate change adaptation frameworks' and transport governance at different jurisdictions in the UK?	□ Discovery □ Complex □ Broad	Qualitative
What factors do influence on the adoption, implementation and integration of climate change adaptation policies into road transport sector policy?	□ Reviewing experience from previous research □ Obtaining experience of transport stakeholders: subjective, complex, discovery, wide range of data is required	Qualitative
Are there any differences in stakeholders' attitudes toward the factors influencing in the process of policy implementation?	□ Subjective □ Comparison □ Narrow focus □ Priorities of stakeholders □ Trade-offs	Quantitative and Qualitative
What institutional arrangement can be suggested for better integrating the climate change adaptation policies within road transport governance?	□ Interpretation: based on the results of previous steps that includes both numerical and non-numerical data	Quantitative and Qualitative

According to Keele (2010), any method that leads to numerical and statistical data is considered to be quantitative. Quantitative approaches answer questions such as "when", "where" and "how many" and are appropriate when the researcher needs to answer the research question with more exact description about the issue; such as "Are there any differences in stakeholders' attitudes towards the factors influencing the process of policy implementation?".

As shown in Table 3-4, neither qualitative research nor quantitative research adequately addresses the research questions. Another approach, mixed-method is a combination of quantitative and qualitative methods in different phases of the research process for collecting and analysing data (Bazele, 2002, Creswell, 2012). The main assumption in using a mixed method in this research is that utilising the advantages of each of these approaches can improve the reliability and the validity of the research (Abowitz and Toole, 2010).

Mixed-method approach has been employed by many scholars in the field of policy analysis, and other related areas such as governance, especially during the exploration of complex research question (Chaney, 2014). Hill and Hupe (2002) suggest mixed-method, quantitative studies backed up by qualitative case studies, when the research involves multiple implementation organisations. Driscoll et al. (2007) argue that mixed-method approach is an appropriate strategy to transform the data for comparison and/or to validate one form of data with the other form. The main disadvantages of mixed-method approach identified by scholars are as follows (Abowitz and Toole, 2010):

- Analysing and integrating qualitative and quantitative data is a complex and time consuming process.
- As a relatively expensive research approach, this type of data collection can force researcher to reduce the sample size or interviewing time.
- Collinearity: due to the correlation of multiple independent variables with a dependent variable together with limitations for obtaining quantised qualitative data for statistical measurement, it is difficult to find which independent variables influence and make a change in dependent variable.

3.6 Choosing Qualitative Methods

This research will employ a combined semi-structured focus group/interview to collect qualitative data. This section discusses these methods and drawing upon the characteristics of these two methods, justifies the chosen approach for the qualitative phase of the research, i.e. combined semi-structured interview/focus group discussions.

Individual interview is a widely used approach to collect qualitative data. Interviews can be categorised into three different forms, structured interviews, semi-structured interviews and unstructured interviews. Table 3-5 compares the characteristics of these methods. As mentioned earlier, the aim of collecting qualitative data is to extract new insights into the implementation of climate change adaptation policies within the transport governance system. Hence, structured interview is not a useful approach for exploring new ideas, since in this technique researcher cannot add questions based on the context of the participants' responses. Unstructured interviews or in-depth interviews are at the opposite extreme. In this type of interview, although interaction between the interviewer and interviewee can reveal new ideas and opinions about the topic of study, because they do not have a narrow scope, they also are not appropriate approach for collecting qualitative data in this study. Hence, this study uses semi-structured interview as the second option for collecting qualitative data from participants.

Semi-structured interviews allow the interviewee to talk freely and openly. At the same time, researchers can collect in-depth information on what they are researching. In this type of interview, the researcher has both flexibility and control of the questions and can change the way the questions are worded and also can adjust the sequence of them. In this type of interview, the ability of the researcher to conduct the interview has been mentioned as the main determinant for collecting rich qualitative data.

Table 3-5: Characteristic of structured, unstructured and semi-structured interview

Structured interview	**Semi-Structured interview**	**Unstructured interview**
□ Pre-defined questions □ Useful technique for	□ Some (key) pre-defined questions □ Interviewer has	□ Interview without the pre-defined questions □ Provide in-depth

finding facts □ Have a narrow focus □ Questions would be asked in the same order for all respondents □ Similar to surveys, Box ticking (by inter-viewer), oral questionnaires □ Without flexibility □ Minimise the effects of the interviewer on the research result □ Easy to quantify and analyse results □ Fast to complete □ Can be replicated	flexibility interviewer can adjust the sequence of questions □ Have flexibility and narrow focus simultaneously □ Drawing on the participants' responses, interviewer can add questions □ Allow open-ended questions (but make the results difficult to analyse) □ Ability of the researcher in conducting the interview is the main determinant in collecting rich qualitative data	understanding □ Have a wide focus □ Sufficient flexibility to extract new insights about the topic □ Difficult to analyse and quantify than structured and semi-structured interview □ Cannot be replicated

Source: (Babbie, 2010)

As an alternative for collecting qualitative data, a focus group is a useful approach in order to obtain a wide range of data through gathering together a number of participants which have a shared experience. According to McLafferty (2004) and Bloor et al. (2001), focus group techniques have been borrowed from marketing research and incorporated into social sciences. The focus group is more than a group interview. The main advantage of focus group interviews is the interaction between participants which allows the researcher to better understand the diversity of participants' experience (McLafferty, 2004, Hague, 2006, Duggleby, 2005). According to Neuman (2007), by employing the focus group method, the researcher provides an environment for participants to ask question one another and explain their answer to each other which in turn can help the researcher in extending the context.

However, focus group method has its own weaknesses. In a focus group only one or a few topics can be discussed: as discussed in Chapter 2, there are many factors which influence the process of the implementation and delivery of the climate change adaptation policies at the local level. Although these factors can be categorised in a number of themes, i.e. scientific barriers, economic barriers, institutional barriers and social barriers, given the linkage between different factors/themes, it can be concluded that the focus group method and its limited time for each participant cannot allow them to cover those linkages during the group discussion (Bloor et al., 2001, Neuman, 2007).

From the above discussion, it became clear that both the focus group and the semi-structured interview can be beneficial for the purpose of the data collection of this research. Table 3-6 shows the advantages and disadvantages of these two methods for collecting qualitative data.

Table 3-6: Advantages and disadvantages of semi-structured interview and focus group discussion

Method	Advantages	Disadvantages
Semi-Structured Interview	✓ Considerable input from each respondent ✓ Can collect supplementary information by follow-up question ✓ There is no peer group pressure that create bias ✓ Respondents discuss without fear	□ High cost □ Time consuming □ The results may contradict each other, hence difficult to analysis □ Getting access to key-informants may be difficult □ Have the potential to reduce the scope and sample for data collection
Focus Group Discussion	✓ Group interaction can reveal diversity of experience ✓ Can provide basic exploratory information ✓ Fewer resource (time and money) is needed in comparison to individual interview ✓ Can provide an environment to articulate attitudes and opinions ✓ Gives researcher new insights; and deep and quick understanding of the phenomenon	□ Focus group members may be difficult to recruit. □ Participants may be reluctant to discuss in a group □ The minority view can be lost □ FGD is subject to bias from dominating respondents □ Results should not generalise from sample group to the larger population as data obtained are context-specific □ Limited range of ideas and information can be

	raised Difficult to analyse data

Source: (Hague, 2006, Byers and Wilcox, 1991, Kaplowitz and Hoehn, 2001, Breen, 2006, McLafferty, 2004, Bloor et al., 2001)

Comparison between these two methods shows that each of them can be a useful method for collecting qualitative data in this research. The focus group method needs less resource than individual interviews. As discussed in the next sections, this research will employ a comparative case study approach in the UK, hence time and money are two determinant factors in choosing the suitable strategy for data collection. Also, the focus group method enables the researcher to obtain the required data (experience) through the interaction between participants which can extend the context of the collected data. In summary, the focus group approach can give the researcher new insights; and deep and quick understanding of the process of the climate change adaptation within the road transport sector.

On the other hand, individual interview method offers its own advantages. The main advantage of individual interviews is that the participants can have sufficient time to discuss different aspects of the process of the implementation of the climate change adaptations policies; since, as discussed in previous chapters, the development and delivery of the climate change adaptation policies at the local level and its integration within the transport governance is a complex process and perhaps participants need more time to discuss the linkages between different factors and relationships.

In order to make a better decision about the appropriateness of each of these methods for the purpose of this research, a pilot study at the University of Ulster was conducted. The participant recruitment process in the pilot study and also in the initial phase of data collection showed that the response rate among participants is very low. On the other hand, it was difficult to find a suitable time and place to meet those participants given that the participants were from different organisations. Hence, it was decided to choose the individual interview as the main method of the qualitative data collection as it can increase the response rate of participation.

3.7 Qualitative Data Analysis

One of the most important steps in the qualitative research process is analysis of data. As discussed previously, this research will use the multiple-case study design to examine the effectiveness of the transport governance arrangements at the local level. Within each case study, semi-structured interviews and focus group discussion approaches are used as the primary source of qualitative data. As a result, it is required to choose an appropriate technique for data analysis.

In practice, there are four choices for analysing the focus group data; memory-based analysis, note-based analysis, tape-based analysis and transcript-based analysis (Krueger and Casey, 2001). The two first techniques have a wide range of error and are not appropriate methods for collecting and analysing the data. In the tape-based analysis, researcher analyses the data after listening to tapes and preparing a brief note of the interview. In the transcript-based analysis, researcher prepares written reports based on complete transcript (Krueger and Casey, 2001). This study will use transcript-based method. Krueger and Casey have suggested using this method in a complex study in which the researcher is trying to understand how different types of people think or feel about the topic under investigation which is exactly compatible with the objective 3 of this research.

A transcript-based focus group data can result 50 to 70 pages of texts and a single interview may run over 20 pages (Srivastava and Thomson, 2009, Onwuegbuzie et al., 2009). Although focus groups have been used for more than 80 years in academic research, there is no systematic framework for analysing focus group data and most of the literature of focus groups has only discussed the formation and conducting the focus groups (Onwuegbuzie et al., 2009, Duggleby, 2005).

However, there are a number of analytical qualitative data analysis techniques that can be used to analyse the data collected in the focus groups and individual interviews. Keyword-in-context, framework analysis, discourse analysis, constant comparison method, and content analysis are the most common methods for analysing the qualitative data.

By employing the '*Keyword-in-Context*' method, researcher pays particular attention to the keywords and aims to know how participants have used them in the context of the study under investigation by comparing the words that appear before and after keywords (Leech and Onwuegbuzie, 2007). According to Onwuegbuzie et al.(2009), this method is based on the belief that people use the same word differently. They argue that because of the interactive nature of focus groups, examination of how words are used in context is necessary. One of the weaknesses of this method can appear when the words collected around the keyword are insufficient. In this situation the phrase can lose its meaning.

Framework analysis is another method for analysing the qualitative data. This method has been used by some scholars in the field of climate change governance (Akompab et al., 2012, Tompkins et al., 2010). According to Srivastava and Thomson (2009), this method involves a five step processes:

1- Familiarisation: gaining an overview of the collected data through listening to audiotapes and reading the transcripts
2- Identifying a thematic framework: the key concepts, issues and themes are used to filter and classify the data.
3- Indexing: identifying portions and sections of the data that correspond to a particular theme.
4- Charting: lifting the data from its original textural context to charts of the themes.
5- Mapping and interpretation through providing the schematic diagrams.

Discourse analysis involves "selecting representative or unique segments or components of language use and then analysing them in detail to examine how versions of elements [...] emerge in discourse" (Onwuegbuzie et al., 2009, p.6-7). By choosing this method for analysing the qualitative data, researcher must pay more attention to the communication between participants. Because this method is not applicable to in-depth interviews cannot be an appropriate approach in this study.

The Constant Comparison Method (CCM) is the most commonly used type of analysis for qualitative data which can be used to analyse many types of qualitative data, including interview and focus group data (Leech and Onwuegbuzie, 2007, Boeije, 2002). On the basis of some criteria such as the data involved, aim, results and research questions, this technique can analyse the qualitative data in three major stages:

1- Coding: chunking data into smaller meaningful parts and labeling each part with a descriptive title
2- Grouping (or axial coding): comparing codes with previous codes and then grouping them into categories, and
3- Developing one or more themes by combining the codes. (Onwuegbuzie et al., 2009).

The codes for undertaking the CCM can be defined deductively (prior to analysis), inductively (during the analysis) or iteratively (Leech and Onwuegbuzie, 2007). These stages can be done via different comparisons within a single interview, between interviews within the same group or from different groups (Boeije, 2002). Although this technique can be useful method for preparing concourses for Q-Methodology, it is not an appropriate technique to combine final results of the study in the interpretation stage; because this technique will not lead to grouping and counting the codes instead it can only create one or more themes from the codes of each focus group and interview.

Classical content analysis as a method for analysing qualitative data is similar to CCM. The main difference between two methods is that in the classical content analysis method researcher counts the number of times each code is utilised instead of creating theme. According to Leech and Onwuegbuzie (2007, p.569) classical content analysis "is helpful to use when there are many codes; it can identify which codes are used most and which might be the most important concepts for the interviewee".

Then, it will be beneficial to employ both constant comparison and classical content analysis methods for analysing the qualitative data in this study. Constant comparison method will be used in order to generate the concourse and Q-set and the content analysis will be used in developing the statements and also in the interpretation of the final findings in order to combine and compare the results of the focus group analysis with the findings of the quantitative methods of this study.

At the initial phase of qualitative data analysis NVivo software were used to create codes and themes from the collected data and scripts. However, because of facing some technical issues while working with the software, it was decided to create themes using paper, whiteboard and Excel software.

3.8 Choosing Quantitative Methods

This research employs a Q-Methodology as the main approach for collecting quantitative data. As discussed in section 3.3, in order to achieve the aim of the research, there is a need to use the advantages of the quantitative methods. The most common quantitative method which has been used in empirical studies is questionnaire (see section 3.2). There is also another quantitative method, known as Q methodology, which is mostly used in psychology. Recently, this method has been used in several transport related or climate change related studies. The two following sections, section 3.8.1 and section 3.8.2, provide the rationale for this selection amongst these two quantitative approaches: questionnaire (or R-Methodology) and Q-Methodology.

3.8.1 Questionnaire or R-Methodology

A questionnaire is a list of written questions that can be completed by many respondents with the presence of researchers (structured survey or face to face structured interview) or without them (postal survey, telephone survey or web-based survey) (Neuman, 2007). Table 3-7 summarises the advantages and disadvantages of this approach for collecting quantitative data.

Table 3-7: Advantages and disadvantages of questionnaire survey for collecting quantitative data

Advantages	Disadvantages
✓ It is an appropriate approach for finding facts and correlating objective variables ✓ Considerable input from a large number of participants ✓ Relatively cost effective method ✓ Requires a short period of time ✓ Easy to quantify and analyse and compare the final results with the results of other research ✓ Can be replicated ✓ The format of questionnaire is familiar to most respondents	□ Needs more participants to reduce the margin of error (minimum 400 participants for 5% error)[38] □ Low response rate which leads to additional error □ Inadequate method to collect data about behaviour, felling etc. □ There is limited possibility for follow-up questions □ Respondents may not think much about the full context of the situation □ There is a level of subjectivity in the interpretation of answers for open ended questions

Source: (Gaffron, 2003, Marshall, 2005, Danielson, 2009, Neuman, 2007)

[38] According to Brown(1980, p.43), the standard error can be calculated using: $e = 1/\sqrt{N}$; where N is the sample size.

Considering the advantages and limitations of the questionnaire method outlined in Table 3-6, and considering characteristics of the research questions discussed in Chapter 1 and section 3.3, it can be concluded that this technique is not a suitable method for this research, because:

(1) It needs more than 400 responses to reduce the margin of error to 5% (Brown, 1980, p.43): A questionnaire survey is a good quantitative research method in order to generate general data from a large number of respondents, e.g. how many municipalities have an adaptation strategy (Lund et al., 2012). Considering the participant selection criteria (having sufficient experience in the process of climate change/transport related policies), it is obvious that there will not be an adequate number of respondents to fulfill this criterion. Hence this method cannot produce a reliable data to find the perception and understanding of actors involved in the transport governance system on the implementation of climate change adaptation.

(2) The questionnaire survey is an appropriate approach for finding facts and correlating objective variables. This research aims to obtain the attitudes of key stakeholder groups in perceiving the problem of the implementation of climate change adaptation policies in each case study area which is a subjective assessment.

(3) Respondents may not think much about the full context of the situation.

3.8.2 Q-Methodology

Developed by Stephenson (1935), Q methodology or Q technique (or simply Q) is an approach that combines the strengths of both quantitative and qualitative methods for studying subjectivity in different research areas (Brown, 1993, Brown, 1996) such as politics (Brown, 1980), health (Diseth et al., 2011), sustainability (Barry and Proops, 1999, Turhan, 2016, Armatas et al., 2016, Metag et al., 2016) and transport (Rajé, 2007). According to the literature, the main difference between Q methodology and R methodology (R) is that unlike the R which correlates the variables, Q is used to correlate the viewpoints, opinions, beliefs and attitudes held by different respondents (Brown, 1980, Nikraftar, 2013, Exel and Graaf, 2005).

Required data for Q methodology is collected by using a technique which is known as Q sorting. In this approach, the respondents (or P-set) are presented with a list of statements (Q sample or Q set) which are a representative set for the whole possible statements about the topic of study. Then, as shown in Figure 1, the participants sort these statements on a quasi-normal and symmetrical sorting sheet (SSS) based on their own perspectives, opinion and interests (De Graaf and Van Exel, 2008). Allowing respondents to frame the issue themselves and thus minimising researcher bias are mentioned as the main strengths of the Q methodology (Brown, 1993).

Q sorting can be conducted in-person or online. In in-person Q sorting, each statement is printed on a card and the sorting sheet is printed on an A3-A2 paper. In online sorting, participants drag and drop each statement on a sorting sheet. The sorting sheet is visible on the screen during sorting, so participants can move statements freely between columns whenever they like.

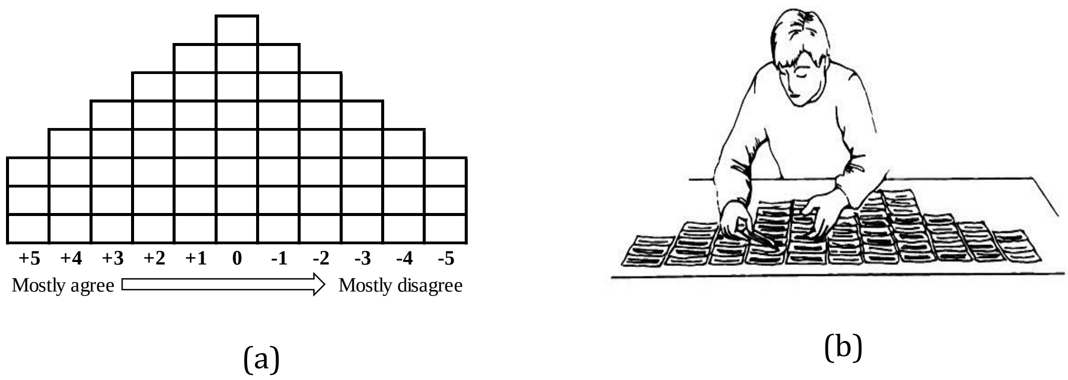


Figure 3-1: (a) Q sorting sheet suitable for 58 statements, (b) Sorting the statements on a forced distribution sheet

Q sorting can be conducted online or in-person. This research has used on-line Q sorting method as the main approach for collecting Q Methodology data. FlashQ software is used as the online Q sorting platform. This software is available at http://www.hackert.biz/flashq/downloads/ for free. However, participants were asked if they like to complete Q sorting using the online or in-person approach. 45 participants completed the survey using the online FlashQ software and three participants (from Cambridge) completed the Q sorting in-person. For More information about online Q-sorting, see Appendix A-5.

Since it has been assumed that a small number of items can be found in the extremes, employing a quasi-normal sorting sheet (bell-shaped diagram) has been suggested to encourage careful thought and to induce the participants to sort statements systematically (Dziopa and Ahern, 2011, Chinnis et al., 2001, Brown et al., 2014). The output of the Q sorting process for all participants is a Q sorting matrix which contains all Q sorts (and scores) of participants. In this matrix, each participant is represented by a column and each statement is represented by a row, hence the Q sorting matrix has NS (number of statements) rows and NP (number of participants) columns.

This study will employ Q-Methodology to analyse and compare the attitudes of different stakeholders towards the governance issues and the implementation of climate change adaptation policies at the city level. Firstly, this method combines the strengths of both qualitative and quantitative methods. In other words, this method can quantify the qualitative data such as perceptions and attitudes and hence the researcher can analyse the data and interpret the findings relatively easily. Secondly, in order to assign a score to a statement, participants need to consider other statements as well. Hence, this method allows maximum flexibility for the participants to consider the context of study. Thirdly and most importantly, Q methodology can work well with a small number of participants to find correlation between them as objectives. For example, Rodriguez-Piñeros et al. (2012) used 36 statements sorted by 20 participants. As another example, Malia and Bennett (2011) used 37 statements sorted by 17 participants. A recent study in the climate change adaptation context has used 22 participants for sorting 24 statements (Hall and Wreford, 2012). So, Q methodology enables this research to collect, analyse and classify different attitudes of transport and climate change policy- related stakeholders towards the barriers to the climate change adaptation at the local level. The following section explains the step by step process of data analysis for Q methodology.

3.9 Analysis of Q-Methodology Data

As discussed briefly in section 3.8.2, analysis of the data obtained from Q methodology (or Q sorting) can be done in four steps. These step are explained in the following sections.

3.9.1 Step 1: Calculation of the Correlation Matrix

The collected data from the Q sorting process are stored in a matrix, known as Q sorting matrix. As mentioned earlier in this chapter, the main difference between the Q methodology and R methodology (Questionnaire) is that Q correlates between participants, while R calculated the correlations over the variables of the study. According to Watts and Stenner (2012, p.97) "*correlation matrix is created through the intercorrelation of each Q sort with every other sort*".

In the first step of the data analysis, the Q sorting matrix is subject to correlation function. The final output is a Symmetrical square correlation matrix which has NP (number of participants) rows and columns. Each number in this matrix shows the similarities between the opinions of a pair of participants regarding the statements of the study (Q set). The correlation coefficient (R) is a number between 0 and ±1. R=0 means that the attitudes of two participants does not have any relationship with each other and on the opposite side R=1 means that two attitudes are completely equivalent. R=-1 means that the attitude of one of those two participants is completely against the attitude of the other participant.

3.9.2 Step 2: Factor Analysis

In this step, the correlation matrix is subject to factor analysis. Although there are different factor analysis methods, this study used the Principle Component

Analysis (PCA), since it is the most frequently used method in Q literature. The outcome of this step is a matrix, with NP latent factors (latent attitudes), which explain 100% of total variability in the correlation matrix. Hence, in this step the total number of attitudes about the statements of the study is equal to the number of participants. However, as the result of using PCA method for factor analysis, each latent factor has a corresponding eigenvalue. The larger the eigenvalue of a factor, the more important that factor is. As a result, the factor analysis allows the researcher to extract the latent attitudes and sort them based on their importance from all participants' point of view. Then the researcher can neglect those factors (attitudes) which are not significant.

Hence, the Q methodology is a data reduction approach, since it only keeps a few number of important factors (larger eigenvalues) to be used in factor rotation step (see the next step). Brown (1980, p.223) states "for purposes of rotation, however, [...] it is best to take out more factors than it is expected ahead of time will be significant. Experience has indicated that "the magic number 7" is generally suitable". Watts and Stenner (2012, p.197) state "if you have some priori substantive knowledge of the data you could use this to inform decision (see Table A2.1 in Watts and Stenner, 2012, p.197). In another section of their book, Watts and Stenner suggest "the magic number 7" to be used for the number of initial factors. Most of the literature has suggested to keep at least 50% of total variance. In other words, the sum of the eigenvalues for the remaining factors should be at least half the total eigenvalues of the initial factor analysis (which is equal to NP/2).

3.9.3 Step 3: Factor Rotation and Varimax Rotation

The aim of the factor rotation in a Q study is to increase the number of Q sorts which can be loaded significantly on the extracted factors (see the Step 4 for more details about the significant loading). Any rotation function, including Varimax rotation, can be represented by a matrix which is known as the rotation matrix (R).

Finding a Varimax rotation matrix (R) is an iterative optimisation problem. There are indefinite number of solutions (rotation matrices), but what the Varimax rotation is looking for is to choose one of these rotation matrixes which can maximise the sum of the variances of the squared correlation between Q sorts and factors (in the new coordinate system or the rotated factor matrix). The outcome of the Varimax rotation function is a set of rotated factors which help the researcher in better understanding and interpretation the factors (See Appendix A-1 for more details). For a specific Q sort (participant), the Varimax rotations aims to produce a large amount of loading on one factor and near-zero loadings on other factors. As a result, the research will be able to easily classify the participants in different groups.

3.9.4 Step 4: Estimation of Final Factors

As mentioned in the previous section, the output of the Varimax function allows the researcher to classify the study participants in different groups. This process is also known as flagging. The aim of flagging (or factor exemplifying) is to find the Q sorts which have been loaded significantly on different factors. Donner (2001b:32) states "this is the step at which you are creating the subgroups and establishing the foundation for the calculation of the distinct "voices" present among your participants". Then, the weighted average opinions of the members in each group is assumed to represent the attitudes of all members. However, there is an initial criterion for each participant to be eligible to enter to the group. It is required that the loading coefficient of a participant viewpoint be greater than a minimum amount, known as significant loading coefficient, which is $SE_r = 1/\sqrt{NS}$ where NS is the number of statements (Brown, 1980). Regarding to the number of groups/factors, it is important to emphasise that, a group should have at least 2 (or in some literature 3) significant loadings. After finding the exemplifiers and loading coefficients, calculation of the factor weights and Z-scores can be easily done to be used in re-sorting the statements from each factors point of view. A complete example of a Q study has been proposed in Appendix to provide the background information about the process of data analysis of Q methodology. These extracted factors are the final output of a Q study which are used in interpretation and categorisation of all participants' opinions. Watts and Stenner (2012) and Brown (1980) have explained the detail of data analysis in Q methodology. Also Donner (2001b) explains the procedure for conducting Q studies.

3.10 Sample Size for Q methodology

As mentioned above, the aim of Q methodology is to reveal the existing viewpoints about a topic and to understand and compare them. Hence, it is used "to identify a typology, not to test the typology's proportional distribution within the larger population" (Valenta and Wigger, 1997, p.501). Therefore, a small number of participants and perhaps even a single individual does not bias Q methodology (Watts and Stenner, 2012, Barry and Proops, 1999). Probably this is why, after more than 75 years of developing Q methodology, there is not a clear-cut rule suggested by pioneers of Q methodology in order to guide researchers in decision making about the number of participants (NP). Different and sometimes inconsistent suggestions have been made in previous studies (Dziopa and Ahern, 2011). Although some literature suggest to relate the number of participants to the number of statements, still there is not a same idea among the researcher regarding this relationship. For example, Thompson et al. (1983) suggest that the number of participants should be about half the number of statements; while Watts and Stenner (2005) recommend that the number of participants (NP) should be similar to the number of statements (NS) (Dziopa and Ahern, 2011).

In order to find a relationship between NS and NP, 36 Q studies were reviewed and analysed. Since, there were not sufficient Q studies in transport or climate change fields to make a robust decision about the sample size, 50 peer reviewed articles in different research areas were chosen randomly. 13 articles that had not stated the explained variance or eigenvalues of the factors were excluded from the analysis. Another four articles had mixed the standard Q Methodology with other methods that were removed from the list. 33 Articles remained for the analysis. Three transport related Q studies (Cools et al., 2012, Cools et al., 2009, Rajé, 2007) were added in later for comparison purposes as shown in Table 3-8.

Table 3-8: List of the reviewed articles which have used Q-methodology

No.	Reference	NP	NS	Var	NF
	Transport				
1	Cools et al. (2012)	33	42	56%	4
2	Cools et al. (2009)	32	42	60%	4
3	Rajé (2007)	50	60	66%	5
	Environment				
4	Hall and Wreford (2012)	22	24	58%	4
5	Frantzi et al. (2009)	25	44	53%	4
6	Curry et al. (2012)	36	50	52%	4
7	Jepson et al. (2012)	21	27	77%	5
8	Asah et al. (2012)	96	60	51%	3
9	Clare et al. (2013)	36	36	70%	4
	Sustainability				
10	Hermans et al. (2012)	36	44	47%	4
11	Cuppen et al. (2010)	75	60	46%	6
12	Mbeng et al. (2009)	30	50	73%	8
	Policy				
13	Ockwell (2008)	32	36	64%	4
14	Buckley (2012)	71	30	64%	4
	Mental and physical health				
15	Sung (2011)	41	33	37%	4
16	Jedeloo et al. (2010)	31	37	42%	4
17	Chang et al. (2008)	22	27	62%	4
18	Malia and Bennett (2011)	17	37	54%	3
19	Diseth et al. (2011)	62	30	49%	3
20	Morecroft et al. (2006)	120	42	73%	5
21	Yeun (2005)	30	40	73%	3
	Farming and forestry				
22	Lansing (2013)	15	30	46%	3
23	Urquhart et al. (2012)	30	36	52%	4
24	Gruber (2011)	30	36	53%	4
25	Kristensen and Jakobsen (2011)	25	27	61%	4
26	Brodt et al. (2006)	40	48	48%	3
27	Hall (2008)	15	48	57%	3
28	Rodriguez-Piñeros et al. (2012)	20	36	65%	3
	Education & research				
29	ten Klooster et al. (2008)	51	30	49%	3
30	Yang and Montgomery (2013)	43	47	45%	2
31	Boscolo and Cisotto (1999)	12	85	78%	2
	Other				
32	Bouwman et al. (2012)	40	48	51%	4
33	Duenckmann (2010)	10	43	63%	3
34	Bryant et al. (2011)	60	50	48%	3
35	Hunter (2011)	30	42	72%	6

36	Cross-Sudworth et al. (2011)	16	36	85%	6

NS: number of statements, NP: number of participants, Var: explained variance

Figure 3-2 shows the relationship between NS and NP in different studies. Obviously there is not a clear regression equation which can produce a high R-squared value. Also, as shown in Table 3-8, there is not a clear rule for decision making about the number of statements (NS) and the explained variance (Var). This issue also has been highlighted in a recent study by Kampen and Tamás (2013).

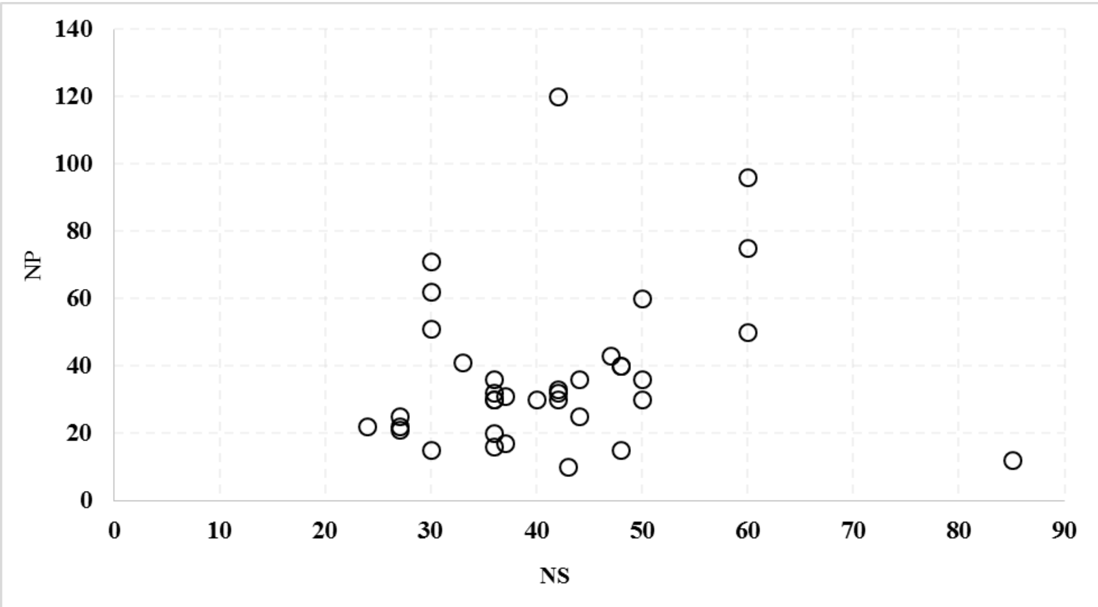


Figure 3-2: Relationship between the number of statements and the number of participants in reviewed articles

(Reference: Author)

Since, the Q methodology fits best with the requirements of this research study which can be used as the main method of data collection and analysis, it is beneficial to better understand the relationships between different variables which influence the results of a Q methodology. Although there are many Q study literature which may be used as the basis for finding this relationship in data analysis process, given that almost all of the published papers do not provide us with the Q sorting matrix (perhaps for ethical issues), it is not possible to investigate the influence of the group of participants (specially Q sorting process) on the results of a Q study. Another barrier for using the literature in finding this relationship is that the empirical data will not produce suitable results to find this relationship. According to Brown (1980, p.234), the reliability of Q methodology is 80%[39]. Brown relates the remaining 20% to "a mood change, the vicissitudes of memory, a different reading of some of the statements, or other "random" effects". So, by using an empirical approach, it will not be possible to recognise whether the change of results is related to the change of dependant variables (NS, NP and Var) or to the vicissitudes of memory of the participants. Hence, it was decided to conduct a simulation method to track the effect of changing each independent variable (number of statements, number of participants and total explained variance), on the results of a Q study. Section 3.11 discusses the simulation process of Q methodology.

3.11 Finding a Suitable Sample Size: Simulation of the Q Methodology

3.11.1 Significance of the Level of Consensus among Participants

As discussed in previous section, in a Q study three independent variables, i.e. NP (number of participants), NS (number of statements) and Var (explained variance), are decided by the researcher. It can be concluded that considering only these variables in the simulation process cannot reflect the influence of the group of participants in the results of a Q study. In order to address this issue, at least another variable from the participants' side is required. Here, the average Spearman correlation between participants (ρ) is used to show the effect of participants on the results of a Q study. The Spearman correlation for rank data or Spearman's rho measures the statistical dependence between two variables (in Q methodology, Q sorts are variables), however, the selection of Spearman correlation instead of Pearson correlation can be justified by considering the fact

---

[39] According Brown(1980), if a participant sorts a Q set a second time, would correlate with his first performance in the amount of 0.80.

that the Spearman's rho calculates the correlation between the 'ranked variables' of the origin data which is more compliant with the nature of ranking the statements in Q methodology. Spearman's rho gives +1 when two 'ranked variables' are completely same, even when the origin data are not (Howell, 2011).

In this study, NF is assumed as a dependant variable of these four independent variables; NS, NP, Var and ρ. Now the first question that may arise is that, in addition to NS, NP and Var, how can Spearman's rho of Q sorts change NF? Although this issue will be discussed further in the next sections, an example can provide the context for the next sections. Suppose that we have a constant number of statements (NS1=NS2), sorted by two groups of participants with the same size (NP1 = NP2), and we are looking for the number of factors (NF) explaining the constant variance of the study (Var1=Var2). Although impossible in reality, assume that all of the individuals in the first group have sorted the statement in the same order (average Spearman's rho=1), and all participants in second group have sorted the statement with different orders with each other (average Spearman's rho<1). Hence, the analysis of Q sorts of the first group will extract only one factor even when the required explained variance is equal to 100%. But the same analysis for the Q sorts in the second group will extract more than one factor. Thus, there is a significant relationship between 'average Spearman's rho' of Q sorts and NF.

3.11.2 Simulation Process

The simulation of the Q sorting process is accomplished using a Monte Carlo method coded in Matlab programming language. Monte Carlo simulation is an widely employed approach to solve engineering and physics problems (Binder and Heermann, 2010, Mahadevan, 1997). The main difference being that the required data can be acquired in 50 iterations, whereas typically Monte Carlo simulations require 300-1,000 iterations. As detailed in the next sections, 50 iterations provides sufficiently robust data to recognise the different clusters among the generated samples within a reasonable timeframe, given the desire to simulate 11,400 samples. This approach means that the required data is generated in a completely random environment, i.e. it is not possible to predict the Q sorting matrix and consequently and consequently it is not possible to predict the extracted factors. But it has one distinguishing characteristic which differentiates it from pure random sorting and covers all the requirements of this study. Although the Q sorting matrix is not predictable, the design of the simulation is achieved in such a way that all four influential variables are predictable / assignable. In other words, the number of statements, the number of participants, the explained variance and most importantly the level of consensus among the simulated participants (average Spearman's rho, ρ) is predictable. Simulation of the three first variables are very straightforward since the sample size (NP), number of statements (NS) and desired explained variance (Var=50%) is specified. The main challenge is how to find a random Q sorting matrix (with NP columns and NS statements) where the consensus level among simulated participants provides a pre-determined value for ρ.

As mentioned above, when all respondents are unanimous about the topic (or statements) the value of ρ is equal to 1 and when there is no consensus among respondents $\rho \approx 0$ (random opinions). Simulation of the Q sorting process in order to reach a pre-determined ρ starts from a unanimous Q sorting matrix (matrix U1, $\rho=1$). If we swap the opinion of a participant about two statements in matrix U1 (where $\rho=1$), the new matrix (U2) will have $\rho<1$ (say 0.999). Repeating this process (selecting one participant/column randomly, selecting two statements/rows randomly, and then swapping the opinions/scores of that participant regarding those two statements) will decrease the value of ρ continually. We can then stop this process whenever we reach the pre-determined ρ. As a result, although the Q sorting matrix is a random matrix and is not predictable, the level of consensus (ρ) is predictable/assignable.

11400 samples (15×19×5×8) were generated by altering four independent parameters as follows: 15 for NS (10, 20,…, 150), 19 for NP (10, 15,…, 100), 5 for Var (0.1, 0.3, …, 0.9) and 8 for ρ (0.1, 0.2, …, 0.8). Each sample is the average of 50 same calculations. The generated data then was exported to SPSS for regression analysis. Since both linear and non-linear regressions didn't produce an acceptable

R^2 value, the data was then analysed using the Neural Network method to compute a non-linear fitting equation for the sample data. The following sections show the findings of this simulation.

3.11.3 Is the Average Spearman's ρ a Significant Variable in Q-Methodology?

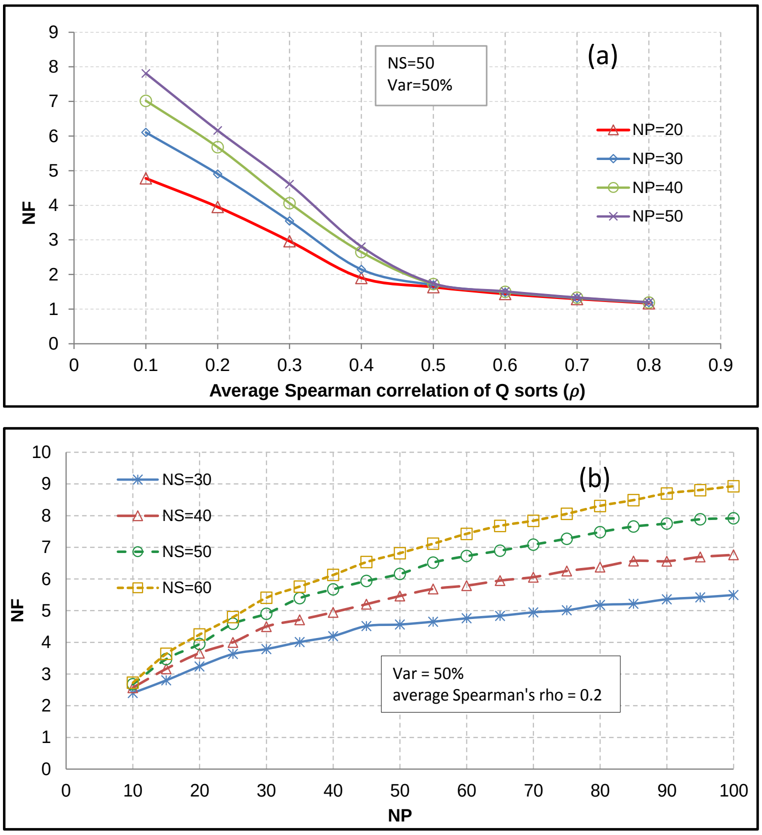
Table 3-9 shows the correlation coefficients between five variables. As expected, there is no statistically significant correlation between any pair of four independent variables. But, all of these variables are significantly correlated with NF as dependant variable. Both Kendall's tau-b and Spearman tests detected this significance too. Increases in NP, NS and Var will increase NF (Pearson>0) and increases in ρ will decrease NF (Pearson<0). This means, if the average Spearman's rho of all Q sorts increases (more consensus among participants regarding the topic), the total number of extracted factors for constant values of NP, NS and Var would decrease. This confirms the example which was discussed in 3.11.1.

Table 3-9: Pearson correlations between pair of variables

Variable	test	*NF*	ρ	*Var*	*NS*	*NP*
NF	Pearson Correlation	1	-0.315[a]	0.667[a]	0.220[a]	0.209[a]
	Sig. (2-tailed)		0.000	0.000	0.000	0.000
ρ	Pearson Correlation	-0.315[a]	1	0.000	0.000	0.000
	Sig. (2-tailed)	0.000		1.000	1.000	1.000
Var	Pearson Correlation	0.667[a]	0.000	1	0.000	0.000
	Sig. (2-tailed)	0.000	1.000		1.000	1.000
NS	Pearson Correlation	0.220[a]	0.000	0.000	1	0.000
	Sig. (2-tailed)	0.000	1.000	1.000		1.000
NP	Pearson Correlation	0.209[a]	0.000	0.000	0.000	1
	Sig. (2-tailed)	0.000	1.000	1.000	1.000	

[a] Correlation is significant at the 0.01 level (2-tailed), N=11400

Figure 3-3(a) illustrates the relationship between ρ and NF when NS=50, NP=20, 30, 40, 50 and Var=0.50. It is obvious from this figure that the increase of the average Spearman correlation of Q sorts is accompanied by a reduction in the NF. Although recruiting more participants in the research (NP) produces more factors in the left part of the chart (ρ<0.5), it does not have a significant impact on NF when ρ>0.5. In practice, in a Q Methodological research, we will usually be in the left half side of the Figure 3-3(a). As will be discussed in the next sections, ρ>0.5 may mean that the Q-sample has not been prepared appropriately and has not had challenging enough statements for participants; which is not the case in Q Methodology. It has been strongly suggested by scholars that the researcher should avoid the statements which everyone (or no one) in the participant list likely to agree or disagree with (Donner, 2001a). In the next sections we will see that the Spearman correlation in different studies is usually between 0.20 and 0.50. One simple function that can fit the diagrams in Figure 3-3(a) is an exponentially decreasing function.



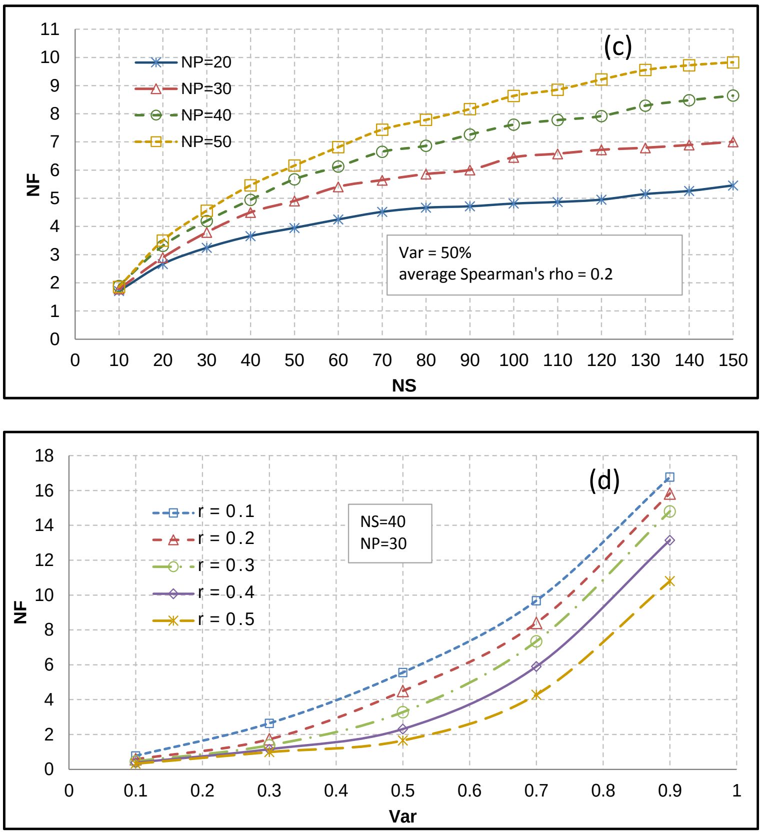


Figure 3-3: Relationship between NF and four independent variables (a) ρ, (b) NP, (c) NS, (d) Var

The relationships between NF and NP and also between NF and NS (Var=50% and ρ=0.2) have been shown in Figure 3-3(b) and Figure 3-3(c) respectively. As seen from these figures, increasing the number of statements or participants will increase the number of the extracted factors for a constant Var (explained variance). In all cases, there is a non-linear relationship that can be fitted by a natural logarithmic function with $R^2>0.9$. For example, the bottommost diagram (NS=30) in Figure 3-3(b) can be fitted by NF=1.362Ln(NP)-0.802 ($R^2>0.99$). Similarly the uppermost diagram in Fig. 2(c) can be fitted by NF=3.094Ln(NS)-5.709 ($R^2>0.99$). Figure 3-3(d) highlights the significant role that explained variance (Var) plays in the number of extracted factors. Each diagram in this figure can be fitted by an exponential function. This figure also reveals that why the researchers suggest to limit the total explained variance to 50% as in deciding to increase the explained variance, will progressively increase the number of required factors.

3.11.4 Finding a Relationship Between Dependant and Independent Variables

3.11.4.1 Regression Analysis

As seen in all plots in Figure 3-3, there is a significant and non-linear relationship between NF and four independent variables. Therefore, finding a linear equation which can properly fit all of the sample data will not be possible. Linear regression analysis by SPSS software confirms this statement by giving an $R^2<0.64$.

On the other hand, doing a non-linear regression (with R^2 near to 1) requires a knowledge of the behaviour of each independent variables on the dependant variable as well as the behaviour of each independent variable on the other independent variables. As shown in Table 3-9, the correlations between independent variables are zero in this study. Hence it would be sufficient to consider only the behaviour of four independent variables on NF. As discussed above, the relationship between NF and two independent variables in Figure 3-3(a) and Fig. 2(d) (ρ and Var) is exponential. Also the relationship between NF and both NS and NP (Figure 3-3(b) and Figure 3-3(c)) is natural logarithmic. Hence, instead of using the values of the independent variables, their corresponding non-linear function were defined and the obtained values were used as independent variables in SPSS to reflect these non-linear relationships. Although the obtained non-linear regression function is better than the linear function, it cannot be used for predicting the number of factors in the future works. Not only did it again not reach an acceptable correlation with the sample data ($R^2=0.678$[40]), but also unclear distribution of the error cannot guarantee that even the function could predict an acceptable and sensible value for NF in a particular study. As an example, sometimes it predicts minus amount for NF. Although combination of all eight variables, which had been used in linear and non-linear regression increased the R^2 value to 0.723, still the issues of unclear distribution of

[40] Although 0.678 may seem to be a high R-squard value, since the simulation of Q methodology in this research aims to develop a model for generalising the Q methodology variables, 0.678 is not considered to be an acceptable value. If this model is used as the predictor, an accurate set of calculations will be required to control the distribution of errors which is out of the scope of this research. Section 3.11.4.2 shows that using the neural network method as a regression method will increase the R-squard value extensively.

error and small R-squared exist. Hence, the Neural Network method was used as an alternative regression analysis method to find a better equation that can be fitted to the sample data.

3.11.4.2 Neural Networks

(a) Neurons, Layers and Neural Network Architecture

A biological neural network consists of a set of interconnected group of neurons that are used in developing an Artificial Neural Network. An Artificial Neural Network (ANN) or simply Neural Network (NN) is an intelligent computational model that simulates the information processing of human brains (Flores, 2011). The first works on this field were published by McCulloch and Pitts (1943) and Hebb (1949,2002) that introduced a biological model of the brain function. This method is being used widely in different disciplines since it enables researchers to recognise a pattern or to approximate a function to a set of input and output data without having the explicit rules between them (Tu, 1996).

Each input or output variable in the data set is modelled by a neuron which sometimes is called 'unit'. Each unit can take one or more inputs, but it produces only one output. These variables form the 'input layer' and 'output layer'. In fact the 'input layer' indicates the information given to a human brain and the 'output layer' represents the commands that the brain sends out.

In order to simulate the functional aspects of the brain in producing the output(s) from input data, another layer(s), known as 'hidden layer(s)', is used. The input layer usually is shown by '*Layer 0*'. This numbering continues until the output layer receives the name of '*Layer N*', where *N* is the number of the layers in the hidden area added by one. Adding more layers (multi-hidden layer) to hidden area can be beneficial when there is strong non-linear relationship between the input and output data that was not the case in our study. In this study we use *N=2* (only one hidden layer in the hidden area) because we could find an average linear relationship between the input and output variables by linear regression. Also the combination of linear and non-linear regressions increased the R^2 value which means that there is not a strong non-linear relationship between the input and output variables. The collection of the neurons and their connections is known as Neural Network Architecture (NNA). Various types of NNAs can be found for a given set of input, output and hidden neurons. In this study, the 'feed-forward network' was employed using Matlab software. In a feed-forward network each neuron gets its value only from the neurons in the previous layer. Each link (arrow) in the network architecture represents the weight of influence of one neuron in the start of the arrow on the neuron which arrow ends.

Figure 3-4 shows the Network Architecture used in this study. The input layer consists of four variables (NR, NS, Var, W); the output layer has only one variable (NF) and the hidden layer comprises of 9 hidden neurons, H1, H2, …, H9 (intermediate variables). The selection of nine hidden neurons in this study will be justified in the following sections by considering the need of the research to accurately predict and generalise. Figure 3-5 shows the impact of the number of hidden neurons on Mean Squared Error (MSE) and R^2.

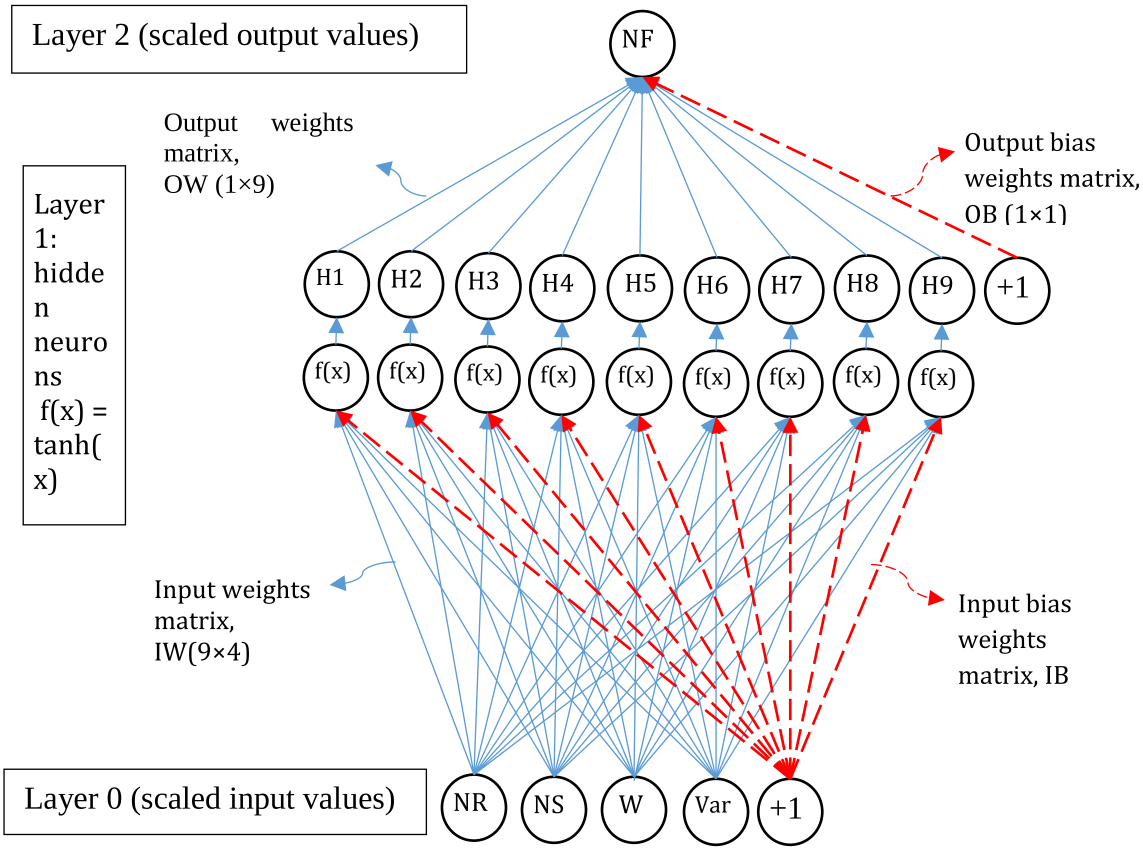


Figure 3-4: Neural Network Architecture (NNA)

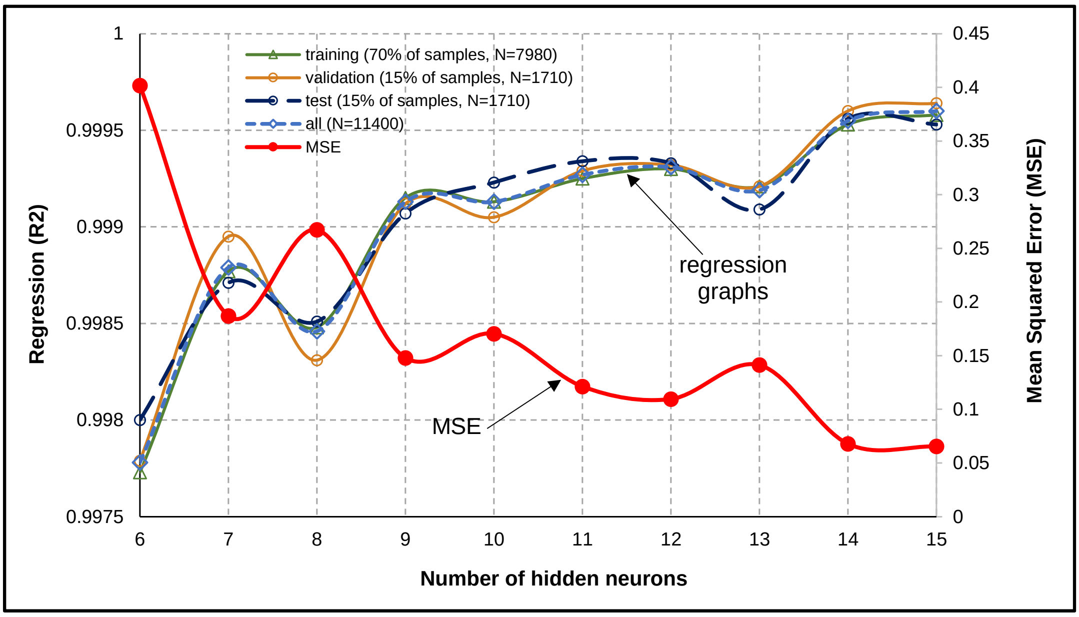


Figure 3-5: Impact of the number of hidden neurons on the Mean Squared Error (MSE) and R2

It should be mentioned that although neural network approach is a strong approach in predicting the output from the input data, it doesn't give a clear explanation of the relationship and this is why sometimes this method has been classified within the 'black box' category of methods (Lee et al., 2005). Structural and functional properties of the neurons in the hidden layer(s) are same as the neurons in both the input and output layers. As mentioned above, each neuron in our study (in the input, output or hidden layer) receives its value only from the neurons in the lower layer. In order to calculate the value for i^{th} neuron in layer p, the perceptron function is used as below:

$$N(i, p) = f(\sum_{j=1}^{m} w_j . N(j, p-1) + b(i, p)) \quad \text{(Eq. 3.1)}$$

Where, m: number of the neurons in layer p-1, w_j: influence weight of j^{th} neuron in layer p-1 on the neuron N_i in layer p, N(j,p-1): value of j^{th} neuron in layer p-1, and b (i,p): bias value of neuron i in layer p. The function f(x) is known as the transfer or activation function (Chen and Fang, 2011). There are different functions that can be used as the transfer function, but according to the literature (Depenau, 1995, Karlik and Olgac, 2011), tanh(x), shown in Eq. 3.2, is often considered the best choice.

$$f(x) = \tanh(x) = tansig(x) = \frac{2}{1+e^{-2x}} - 1 \quad \text{(Eq. 3.2)}$$

(b) The learning process

In the first stage of the learning process of the neural network, it is required to scale the values of the input and output neurons in the range [-1,+1] to overcome the problem of different magnitudes and units among the variables. Then, the computation of neuron values start from the neurons in the input layer (with the scaled value) by giving the random weights to all arrows in the network architecture (like a new-born baby's brain). The result of this process (from input layer to hidden layer and then from hidden layer to output layer) is the first predicted output matrix which has the same size with the expected output. In the next step, the 'backward propagation of errors' algorithm, or simply back-propagation, is used to adjust the specified weights and minimise the differences between the expected and predicted matrixes (Fausett, 1994). Mean Squared Error (MSE) function is usually used to compare the consistency between two matrixes. This process continues until the error function reaches the minimum possible level (Ripley, 2007). The general equation used in this study is:

$$Y = OB + OW \times tansig\left(IB + IW \times X\right) \quad \text{(Eq. 3.3)}$$

By using the 11,400 simulated samples, the following non-linear multivariate regression equation was extracted:

$$NF = -13.949 + \begin{bmatrix} -43.119 \\ -26.452 \\ 14.732 \\ -2.502 \\ -27.568 \\ 25.252 \\ 30.333 \\ -29.788 \\ 68.885 \end{bmatrix}' \times \tan sig \left(\begin{bmatrix} -0.466 \\ 0.223 \\ 0.624 \\ 0.459 \\ -3.030 \\ -3.009 \\ 3.003 \\ 0.999 \\ -0.196 \end{bmatrix} + \begin{bmatrix} 0.974 & -1.296 & -0.064 & 0.015 \\ 1.277 & -1.524 & 0.037 & 0.049 \\ 0.923 & -0.785 & 0.072 & 0.224 \\ 1.733 & -1.584 & -0.839 & 0.622 \\ -0.597 & 1.585 & 0.506 & -0.810 \\ -0.392 & 2.267 & 0.400 & 0.162 \\ 0.482 & -1.021 & 1.200 & -0.358 \\ 0.687 & -0.954 & -0.131 & -0.092 \\ 0.948 & -1.251 & -0.077 & -0.003 \end{bmatrix} \times \begin{bmatrix} (20\rho - 9)/7 \\ (10Var - 5)/4 \\ (NS - 80)/70 \\ (NP - 55)/45 \end{bmatrix} \right)$$

(Eq. 3.4)

Figure 3-6 shows the excellent consistency between expected and predicted output and compares it with the results from the linear and non-linear regressions. It can be concluded that by having four independent variables, the number of factors can be predicted. This equation has been used in section 5 to find ρ from known values of *NS*, *NP*, *NF* and *Var*.

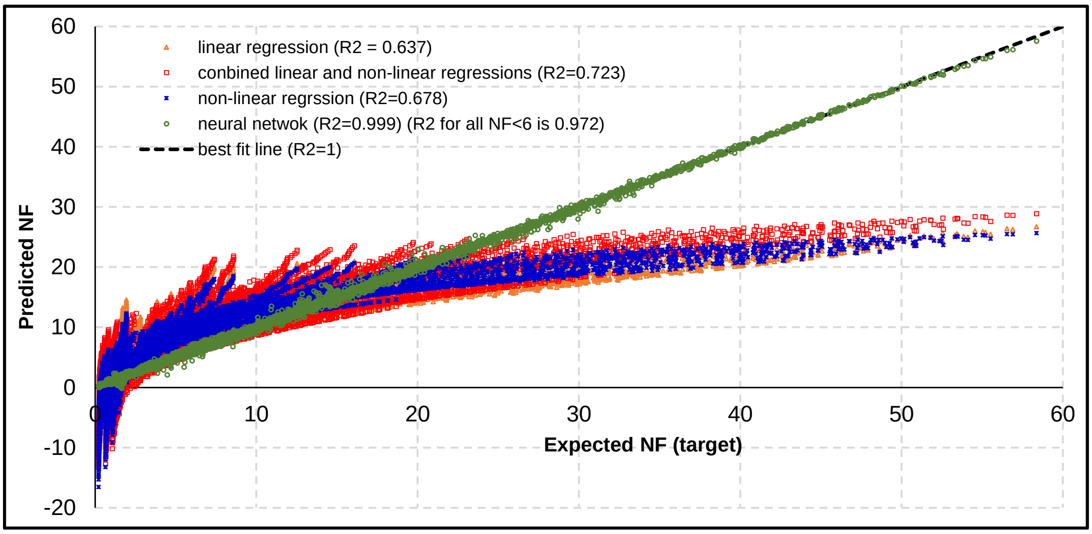


Figure 3-6: Regression coefficients between expected and predicted NF in different methods (N=11400)

It should be emphasised that, although E.q 3.4 produces a high regression coefficient when comparing the expected and predictions, this formula is just an estimation of can only be useful to calculate an "estimation" for a Q study variable when other four variables are available. Also, when using this formula, it is important to consider the range of all variables used in neural network simulation. For example this formula cannot be used when number of participants are more than 100. In this situation, all steps explained in neural network simulation and sample creation steps should be followed to create a new data set, new neural network model and new formula.

(c) Model Selection

Increasing the number of hidden neurons will increase the number of regression parameters (weight and bias coefficients). This as a result leads to a decrease in MSE and an increase in R^2. But it doesn't necessarily mean that having more hidden neurons in the model is better than less. Because it may reduce the ability of model in generalisation and forecasting (Lawrence et al., 1997). Several theories have been developed to determine the optimal network size. Akaike's Information Criterion (Akaike, 1973, Akaike, 1992), Takeuchi's Information Criterion (Takeuchi, 1976) and Second-Order Information Criterion (Sugiura, 1978). In this study, Akaike's Information Criterion (AIC) is used in order to measure the goodness of the model. AIC is a relative measure of information lost in describing a reality by a model. AIC is not a test, rather it is a method for ranking the proposed models. A model with the minimum AIC fits better to the data (Panchal et al., 2010). AIC can be found using the following equation (Burnham and Anderson, 2002):

$$\mathrm{AIC}=\mathrm{n}\times \mathrm{Ln}(\frac{RSS}{n})+2\mathrm{K}=\mathrm{n}\times \mathrm{Ln}(MSE)+2\mathrm{K} \qquad \text{(Eq. 3.5)}$$

Where n is the sample size (11400), RSS and MSE are the residual sums of squares and the mean squared error (between output of the model and target), and K is the number of parameters in the model (in this study K= 6Nh +1, Nh: number of hidden neurons). In this study I suppose that the increasing the number of hidden neurons from 9 to 1900[41] will decrease the MSE in a linear fashion from 0.148 to 0. Hence the following equation can be found between MSE and Nh.

$$MSE=-7.83\times 10^{-5}N_h+0.149 \qquad \text{(Eq. 3.6)}$$

AIC can be calculated by substituting Eq. 3.6 into Eq. 3.5:

$$AIC=11400Ln\left(-7.83\times 10^{-5}N_h+0.149\right)+12N_h+2 \qquad \text{(Eq. 3.7)}$$

The relationship between AIC and N_h has been shown in Figure 3-7.

[41] 1900 hidden neurons is sufficient for producing K=6×1900+1=11401 parameters, and these parameters are sufficient in finding a regression equation with R^2=1.

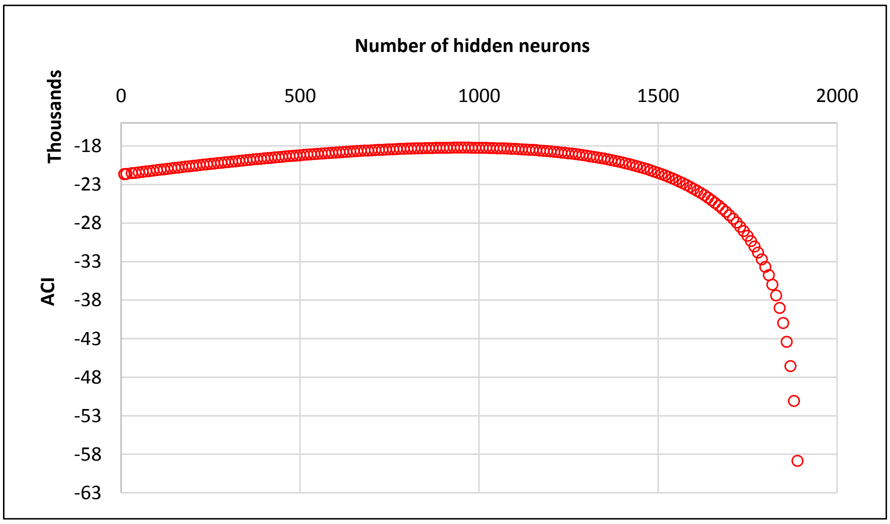


Figure 3-7: Relationship between the number of hidden neurons and AIC

As shown in Figure 3-5, when the number of hidden neurons is less than 9, the R squared value will be less than 0.999. In this study we assume the 0.999 as the minimum acceptable R squared value. Hence the number of hidden neurons must be more than or equal to 9. On the other hand, as illustrated in Figure 3-7, increasing the number of hidden neurons to above the 9 does not decrease the AIC value, meaning that 9 is the optimal number of hidden neurons to reach the R^2>0.999.

3.11.5 Suggestions about the Sample Size

Eq. 3.4 was used in order to find the average Spearman ρ in 36 Q studies reviewed in section 3.10 through employing the Bolzano's Theorem (Eriksson et al., 2004, p.216). Results show that the average Spearman's ρ changes from 0.03 (Sung, 2011) to 0.70 (Boscolo and Cisotto, 1999). Not really surprising, this means that the topic under investigation is an important factor that directly influences the average Spearman's ρ of the Q-sorts and consequently changes the number of factors (NF) and explained variance (Var). Although ρ changes in a wide range (from 0.03 to 0.70), as shown in Figure 3-8, in 26 articles (out of 36) it is between 0.20 and 0.50. Average ρ between all articles is 0.35 (σ=0.15). Drawing upon the value of standard deviation of ρ in 36 articles (σ=0.15), we classified these articles into four groups as shown in Figure 3-8.

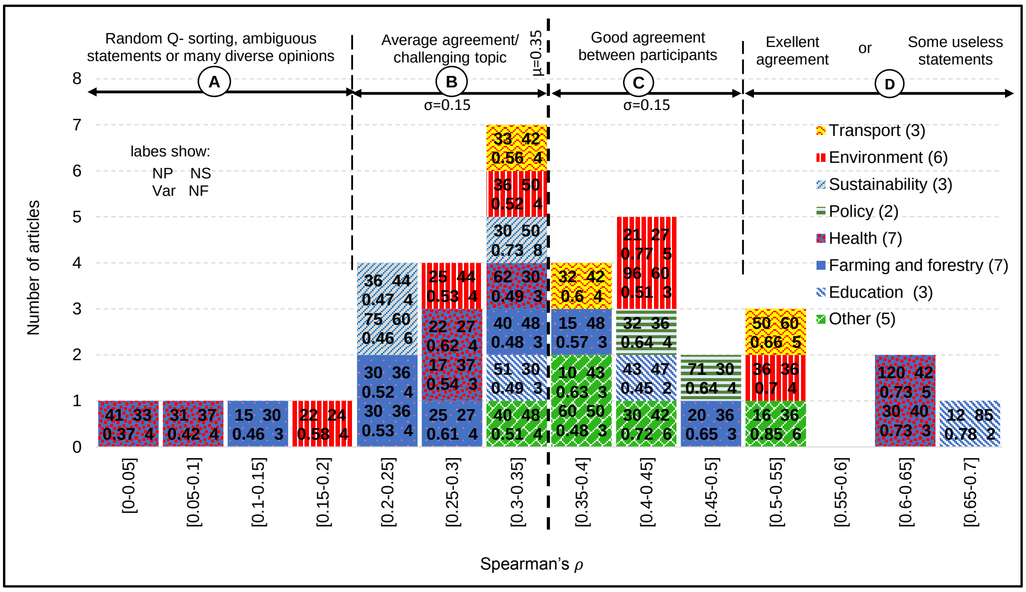


Figure 3-8: Spearman's ρ value in different Q studies

Table 3-10 shows the average of three independent variables in four defined ranges. As shown in Table 2, although the researchers have chosen a wide range for both NP (between 10 and 120) and NS (between 24 and 85), the results in Table 3-10 indicate that there is a harmonious relation between the averages of these variables chosen for articles in different ρ ranges. This provides evidence to Q researchers that the application of Q methodology in social sciences has passed the infancy stage.

Table 3-10: Comparison between independent variables in 36 Q-studies in different ρ ranges

Range	N	*Avg(NP)*	*Avg(NS)*	*Avg(Var)*
range A $0.00<\rho<0.20$	4	27.25	31	0.46
range B $0.20<\rho<0.35$	15	36.80	40.60	0.54
range C $0.35<\rho<0.50$	11	39.09	41.91	0.60
range D $0.50<\rho<0.70$	6	44	49.83	0.74
All ranges	36	37.64	41.47	0.58

As expected, total explained variance increases alongside ρ. Except one article (Hall and Wreford, 2012), all articles in range A have not reached to the acceptable Var=50% even by recruiting a small number of participants. It can be concluded that, in range A, in addition to a small number of participants, researchers should reduce the statements as many as possible to conduct a more focused research study in order to be able to explain at least 50% of the variance by a reasonable number of factors. It also will be beneficial for the researcher double check the clarity and unambiguousness of the statements.

Furthermore, as we know, the Spearman correlation between two randomly generated data is near to zero. In Q context, this means that there are many diverse opinions on the topic. Hence, when $0<\rho<0.20$, it is strongly recommended to validate the results of the study with the results of another semi-quantitative method such as Framework Analysis method (Srivastava and Thomson, 2009) or Classical Content Analysis (Leech and Onwuegbuzie, 2007) in order to enhance the reliability of the results by scientifically rejecting the view that participants have not read statements carefully or have not spent sufficient time in the Q sorting process. The reason for this is because even when we ask participants to sort the statements without reading them, we can extract some factors with some eigenvalues greater than 1. That is why Horn introduced the parallel analysis test for deciding about the number of factors in factor analysis (Horn, 1965).

In contrast, articles in range D explain a higher amount of variance (averagely 74%). Studies in this range allow the researcher to have more statements and (or) recruit more participants to explain an acceptable amount of the variance by a small number of factors. Results of the studies in range D are reliable and do not need to be validated by the results of other methods. The only concern for the studies in range D is that in some studies a considerable number of statements are not challenging for participants and probably are not useful for the researcher. This issue increases the explained variance deceptively. As an example, although Boscolo and Cisotto (1999) do not discuss the sorting sheet and factor arrays, by using the given Z-scores, it can be calculated that more than 40 percent of the statements in a Q sample have been agreed or disagreed with all participants which seems to be a large number even for two-factor solution. It should be mentioned again that the Q-methodology is not a confirmatory method for hypothesis testing. Rather, it is a systematic approach for generating a typology of attitudes. Hence, the researcher should avoid those statements that are likely to be agreed or disagreed with by all of the participants.

Ranges B and C have intermediate situations in comparison to ranges A and D. Studies in range B are usually about a challenging issue. Similarly to range A, we suggest that the results of Q method for studies in range B should be validated by the results of another qualitative or quantitative method. Results of the studies in range C have acceptable reliability. This does not mean that the average Spearman's rho between Q sorts is the only criteria for testing the reliability of a given study. But at least it can be said that in ranges C and D, researchers have used unambiguous statements and almost all participants have read statements carefully. Table 4 shows the number of required participants to explain at least 50% of the variance by 3, 4 and 5 factor solutions.

Table 3-11: Number of participants required in a Q study to explain 50% of variance

ρ	NF	NS	NP range	ρ	NF	NS	NP range	ρ	NF	NS	NP range	ρ	NF	NS	NP range
Range A (0< ρ <0.20)	3	20	17-36	Range B (0.20< ρ <0.35)	3	25	25-90	Range C (0.35< ρ <0.50)	3	30	62->100	Range D (0.50< ρ <0.70)	3	35	>100->100 (*)
		25	11-25			35	15-49			40	41->100			45	
		30	8-19			45	10-36			50	32->100			55	
		40	6-12			65	8-24			70	23->100			75	
	4	20	40-77		4	25	52->100		4	30	>100->100		4	35	
		25	27-52			35	32->100			40	88->100			45	
		30	21-40			45	23-74			50	65->100			55	
		40	14-27			65	16-48			70	44->100			75	
	5	20	80->100		5	25	91->100		5	30	>100->100		5	35	
		25	50-91			30	68->100			40	>100->100			45	
		30	37-67			40	46->100			50	>100->100			55	
		40	25-46			65	26-83			70	76->100			75	

(*) >100 represents a number larger than 100. In this study, the number of participants was limited to 100 in the created Neural Network model. Hence, it is not possible to predict the exact value of NP>100.

3.12 Shape of the Sorting Sheet

Q methodology is a mixed method since it joins the qualitative Q sorting and quantitative factor analysis and Varimax rotation approaches, i.e. Q collects the required data qualitatively and analyses them quantitatively. In doing so, it combines the qualitative and quantitative parts in the scaling and scoring phase. The role of the shape of the "forced" sorting sheet is very important in converting the qualitative opinions to quantitative ones since the scores on a Q sorting sheet are interpreted as the scores which participants are giving to those statements[42]. Each participant has a "real" viewpoint about the proposed statements which the researcher cannot predict. When participants are asked to reflect their viewpoints on a "forced" distribution sheet, they have to convert their "real" viewpoints to the closest viewpoints which can be figured by that forced distribution sheet. As a result, the forced distribution sheet has a simplifier role in data collection and loses some data when converting the real data (participant's real viewpoint) to collected data (the closest viewpoint to the real viewpoint). In another words, the collected data is not a complete match with the real data.

3.12.1 Simulation of the Q methodology: Effect of the Sorting Sheet

The aim of this section is to better understand the impact of the shape of a symmetrical sorting sheet (SSS) on the results of a Q study. In other words it evaluates the effectiveness of using forced distribution sheets to transform the "real" qualitative data into data which can be analysed quantitatively. In doing so, it discuss the extent to which this simplification of the data collection process using forced distribution sheets is changing the extracted factors (attitudes) of a Q study, examining the extent to which the results (extracted factors) are changed should the researcher adapt the shape of the sorting sheet. In order to achieve this aim, again a simulation approach is used.

The process of simulation is similar to what which was explained in section 3.11.2, but with some small differences. Firstly, the desired explained variance (Var) is assumed to be constant (Var=50%). Secondly, two other variables need to be considered which are number of columns in the sorting sheet (NC) and Slope of the sorting sheet. The variable "Slope" is defined to reflect the steepness or shallowness of the sorting sheet. "Slope" is equal to 0 when all columns of the SSS have same number of cells. If we call the middle column as i=0, Slope=1 means that column number i has one more cell than column i+1. Slope=0.5 means that column number i has one more cell than column i+2. Slope=1.5 means that column number

[42] If the participants are not provided with these scores by the researcher, the researcher will give a score to each column during the data analysis.

i has three more cells than column number i+2. And finally Slope=2 means that column number i has two more cells than column number i+1. It should be noted that it is impossible to design a SSS exactly consistent with a predefined "Slope" since the number of statements and the number of cells in each column of the sorting sheet are not continuous variables, rather they are discrete variables. So, the real slope of the generated SSS will be a bit different from what we report in the next sections. However, as we will see, this change will not have any influence on the results of this study. Thirdly, instead of using the Spearman correlation coefficient, Kendall's coefficient of concordance (KW) is used. These two variables are interchangeable by using the flowing equation:

$$KW = \frac{\rho \times (NP - 1) + 1}{NP} \qquad \text{Eq. (3.8)}$$

KW is an indicator which assesses the agreement level among more than two participants. When there is no consensus among respondents KW≈0 (random opinions); and when all respondents are unanimous about the topic (or statements) the value of KW is equal to 1; hence 0≤KW≤1 (Field, 2005, Legendre, 2005, Malvern and Skidmore, 2001, Howell, 2011). KW can be calculated by using Eq. (3.9) (Howell, 2011, p.321):

$$KW = \frac{12 \times \sum T_i^2}{NP^2 \times NS \times (NS^2 - 1)} - \frac{3 \times (NS + 1)}{NS - 1} \qquad \text{Eq. (3.9)}$$

Where T_i (i=1, 2… 32) represents the row totals in Q sorting matrix, NS= number of statements and NP= number of participants.

Fourthly and most importantly, it is required that the simulation process allow the researcher to re-sort the statements from a specific participant's point of view on different sorting sheet. As discussed earlier in this section, I aim to investigate the impact of the sorting sheet on the reliability of Q methodology. In order to achieve this aim, I must be able to simulate a group of participants which sort statements using a range of different distribution sheets. In reality, each participant has a unique preference number for each statement. In other words, even if a participant put two statements (e.g. say statement 10 (S10) and statement 18 (S18)) in the same column of the sorting sheet, it does not mean that this participant has a uniform opinion of each, even when forced to allocate the same score for each statement. Rather, it means that the instrument used to obtain this participant's opinion is not accurate enough to capture the small differences between the scores. For example, if we ask him/her to choose only one statement between S10 and S18 (which were put on same column of the distribution sheet), he/she will be able to choose one, even if his/her opinion about S10 and S18 has only a single epsilon of difference. This has one helpful consequence for this study. It can be said that it is not possible to accurately re-sort one participant's opinion on a new sorting sheet by using the information which was obtained from another Q sorting sheet. In order to overcome this problem, a preference matrix is used. This matrix is similar to the Q sorting matrix with one difference. In this matrix, no two statements have same scores, i.e. the number of columns in the sorting sheet is equal to the number of statements (most accurate measurement tool/sorting sheet). Hence, by using this accurate measurement tools, we will be able to re-sort the statements from each participant's point of view on different Q sorting sheets.

In order to increase the reliability of the results of this study, 13475 (7×7×5×11×5) Q studies are simulated through altering the "NP: number of participants" (20, 30,… 80), "NS: number of statements" (20, 30, …80), "NC: number of columns in the sorting sheet" (5, 7, 9, 11, 13), "KW: consensus level among the participants" (0, 0.1, …, 0.8, 0.9, 0.99) and "Slope" (0, 0.5, 1, 1.5, 2). Figure 3 shows the algorithm for the sample creation, data analysis and result comparison. In the next section, the step by step process of simulation has been discussed within two illustrative examples in order to assess the twin capabilities of Q (Q as clustering method, and Q as attitude exploration method) by employing only N=2 symmetrical sorting sheets (SSS1 and SSS2). Also, these examples enable the researcher to better understand the reliability indicators for Q methodology and their measurement methods.

Results of each simulated sample are compared with N=24 (NC×NSlope-1=5×5-1) samples which have same NP, NS and preference matrix (and consequently the same KW). By doing so, the average correlation, the minimum correlation and the standard deviation between the extracted factors of each of the study pairs were obtained and compared as explained in section 3.12.2.1(a). Also the matrix of exemplifier for each sample were compared with the corresponding exemplifier matrices of the samples with same NP, NS and preference matrix as discussed in section 3.12.2.1(b). In this simulation, the averages of the results from 5 iterations (5×13475 samples) have been used for data analysis.

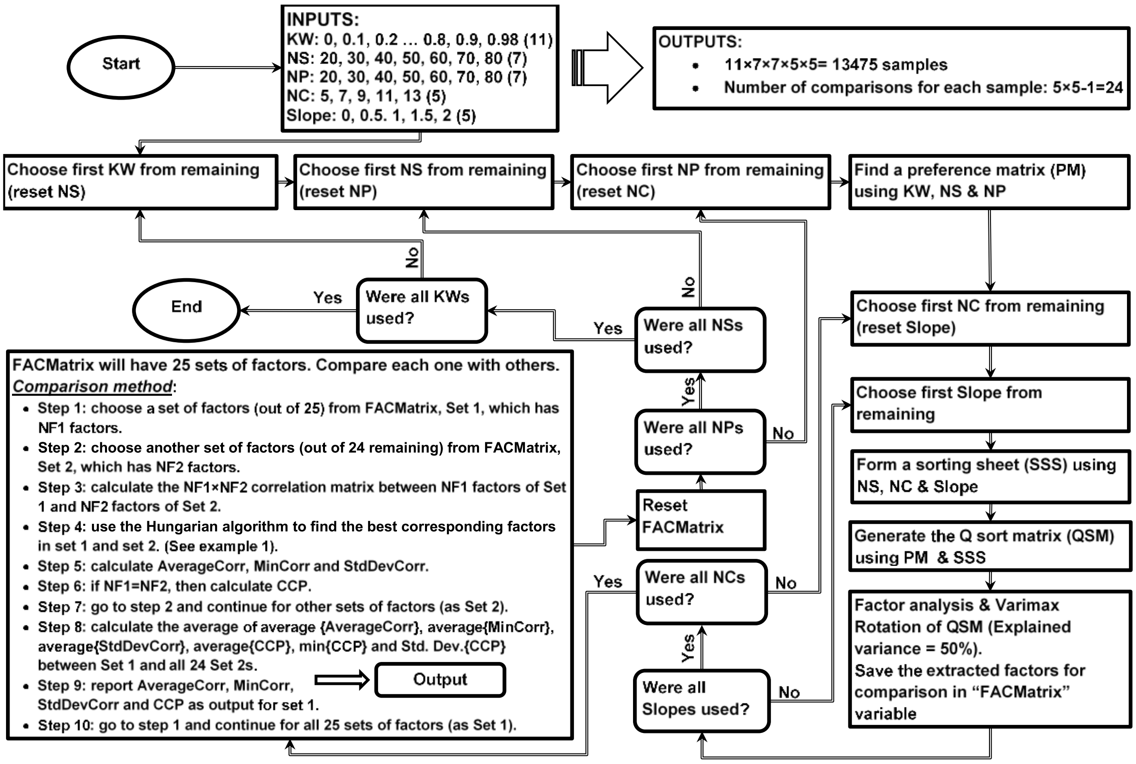


Figure 3-9: Simplified algorithm for generating the required samples

3.12.2 Reliability Indicators and Reliability Measurement

The following section discusses the reliability indicators for Q methodology and develops a numerical method for each indicator. All methods which are used in this section and its examples, will be used to simulate the required samples of this study.

3.12.2.1 Example 1: Random Opinions

Suppose that NP=25 participants (Group 1: P1, P2… P25) have been asked to sort order NS=36 statements about topic A on a Symmetrical Sorting Sheets (SSS1) as shown on Figure 3-10(a). Then they are asked to distribute same statements on another sorting sheet, SSS2, as shown in Figure 3-10(b). Sorting the statements on each SSS is considered as a separate study. The aim is to extract the main attitudes among participants which explain at least 50% of each study's variation (Var=50%). Hence we are conducting N=2 Q studies, but the statements and the participants are same. The only difference is the sorting sheet used in each study.

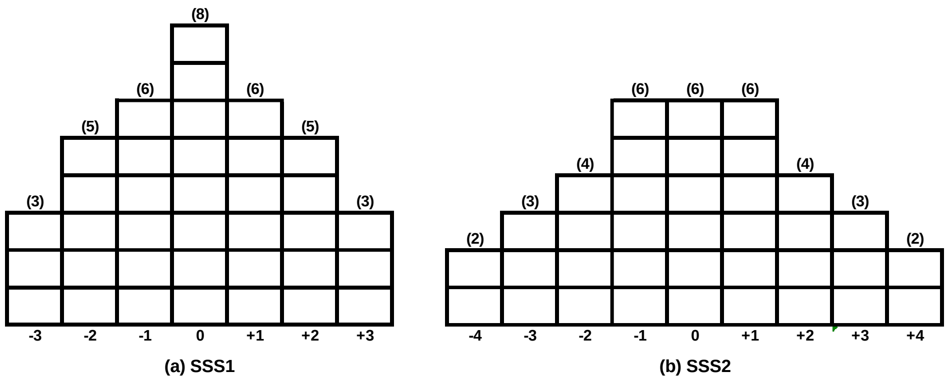


Figure 3-10: Two SSSs suitable for sorting 36 statements

If Q is a reliable methodology, the expected outcome would be that each extracted factor from each study would be highly correlated with one of the extracted factors of another study and hence the same attitudes would be revealed. If this wasn't the case, then we can propose a hypothesis that changing the sorting sheet can change the results (extracted attitudes) of a Q study. As discussed in Section 3.12.1, in order to simulate the participants' preference in sorting the statements, a preference number is given for each of these statements from each individual's point of view as shown in Table 3-12. For example, as highlighted in Table 3-12, for the participant 5 (P5), the statement 3 (S3) is in the 9th place of the preference list between all 36 statements. This table is a random preference matrix which represents a group of participants that have completely different opinions (KW=0.03). As we see numbers in each column are unique which allows us to resort the statements on any sorting sheet suitable for 36 statements, including SSS1 and SSS2, from these 25 participants' points of view.

Table 3-12: Preference numbers for 25 participants (Group 1) over 36 statements

S / P	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21	P22	P23	P24	P25
S1	24	24	16	14	18	16	27	32	14	20	5	6	35	12	33	34	30	7	29	31	9	16	7	3	16
S2	17	34	4	18	24	36	1	35	22	13	20	3	13	15	1	16	5	5	25	34	23	34	19	19	36
S3	32	8	5	35	9	26	3	28	34	25	30	9	20	19	34	23	26	3	14	20	5	8	25	33	29
S4	9	21	26	5	32	20	19	34	32	9	21	4	30	4	10	11	6	1	23	19	30	1	9	35	18
S5	3	20	8	17	10	21	31	6	28	30	26	25	12	33	8	24	4	24	36	6	20	22	15	18	10
S6	23	11	6	3	35	17	24	20	23	12	28	26	17	6	11	20	32	15	31	33	10	36	26	1	19
S7	22	31	9	16	6	27	17	22	35	29	12	17	15	35	19	4	8	22	5	22	35	14	30	20	32
S8	18	17	30	28	33	1	4	25	7	11	27	5	25	11	6	29	24	34	6	26	12	25	14	2	35
S9	25	5	34	30	5	13	32	9	20	33	29	20	19	21	9	14	20	14	19	21	32	10	10	8	28
S10	16	30	20	12	17	19	25	11	8	21	36	11	34	28	36	27	3	29	8	27	14	35	22	21	13
S11	2	10	23	22	3	24	7	15	9	36	24	13	21	5	4	33	12	4	26	23	36	24	5	14	4
S12	26	16	27	15	7	6	28	30	16	14	3	28	22	30	27	2	21	18	17	32	21	21	28	23	24
S13	33	29	1	25	1	11	14	3	33	16	13	10	3	31	31	25	16	16	7	15	17	13	34	22	11
S14	27	1	15	27	4	14	5	16	27	34	14	29	14	7	14	19	10	9	34	11	29	26	35	28	1
S15	11	25	33	23	34	34	35	29	18	15	34	12	31	29	16	12	7	28	33	12	13	32	6	25	30
S16	14	7	18	36	36	22	12	26	15	2	25	19	23	26	29	1	1	35	20	7	31	19	20	34	26
S17	35	9	13	34	30	9	23	1	25	32	19	7	8	34	30	5	22	36	3	9	16	5	21	9	9
S18	8	4	29	24	14	10	34	19	6	5	10	14	2	18	25	35	14	32	9	5	18	12	17	10	17
S19	5	28	2	10	27	5	30	18	4	24	8	31	27	13	21	15	28	11	35	29	27	6	29	24	34
S20	19	26	17	13	26	12	16	5	30	6	17	36	26	8	26	21	31	2	2	17	22	27	32	17	22
S21	36	6	32	20	20	8	15	24	31	8	4	32	18	27	5	7	9	25	18	25	1	7	3	27	20
S22	15	12	35	11	29	30	36	21	2	18	35	1	24	9	12	28	34	31	13	14	11	15	33	16	3
S23	7	19	19	9	19	3	10	33	29	27	18	33	11	36	20	8	19	10	24	18	33	30	12	5	23
S24	28	32	3	2	21	28	2	27	11	35	23	34	5	2	22	9	33	23	30	4	3	3	18	31	21
S25	20	15	7	1	8	4	33	14	1	1	22	18	7	1	17	32	17	20	16	28	4	31	1	6	8
S26	4	27	12	26	28	18	9	17	17	26	2	27	36	20	15	3	11	12	4	3	24	9	36	36	2
S27	10	3	24	31	15	2	13	31	3	7	7	30	10	32	13	22	35	30	10	30	6	28	2	15	25
S28	29	36	10	4	12	31	29	13	10	10	15	2	9	24	35	10	36	33	27	1	2	18	31	32	7
S29	34	14	28	19	31	32	8	10	5	3	32	8	32	22	18	26	27	8	12	2	8	17	13	13	5
S30	21	23	36	8	25	7	20	12	26	4	9	21	4	23	32	36	23	6	21	36	7	33	23	12	14
S31	1	18	14	21	11	25	11	8	12	17	1	23	33	17	3	31	13	26	32	24	34	29	27	29	12
S32	31	33	25	6	2	35	22	2	19	22	33	16	16	10	24	6	15	17	15	35	25	23	16	11	15
S33	13	22	11	7	13	33	6	4	36	28	6	24	1	3	2	17	25	27	28	8	15	11	11	4	27
S34	12	2	31	33	23	15	18	36	24	31	31	35	6	14	7	13	2	19	11	13	28	20	8	7	6
S35	30	35	21	29	22	23	21	7	13	19	16	15	29	16	28	30	29	13	22	16	26	4	4	30	31
S36	6	13	22	32	16	29	26	23	21	23	11	22	28	25	23	18	18	21	1	10	19	2	24	26	33

After re-sorting the statements on SSS1 and SSS2, the Q factor analyse method can be applied on the Q sorting matrices of the two studies using Principle Component Analysis (PCA) with a Varimax Rotation. Here, only the table of exemplifiers (Table 3-13) and the extracted factors (Table 3-14) for each SSS have been shown. Appendix A-1 includes all steps of the analysis for this example. Table 3-13 shows how participants have been categorised into different groups and Table 3-14 shows what the representative attitude of each group is. For now ignore the different colours (or shapes) shown in these tables since they will be discussed in more detail in section 3.12.2.1(a). The important issue which should be emphasised here is that by changing the sorting sheet from SSS1 to SSS2, there is a huge change in results of this study. For example, attitude F1 in Table 3-13(a) (from sorting sheet SSS1) represents six participants (P4, P14, P16, P19, P22 and P24). However, by using SSS2 (Table 3-13(b)), these six participants are no longer in the same group and have been grouped in three different categories (F1, F3 and F5).

Table 3-13: Exemplifiers

(a) SSS1

F1 ○	F2 △	F3 ◇	F4 ▭	F5 »	not loaded	confounded
P4	P1	P2	P5	P8	P7	
P14	P10	P3	P6	P20	P9	
P16	P15	P18	P11	P25		
P19	P17	P23	P12			
P22	P21		P13			
P24						

(b) SSS2

F1 ◇	F2 △	F3 ○	F4 »	F5 ▭	not loaded	confounded
P6	P1	P4	P5	P3	P7	P2
P20	P15	P14	P8	P9		P25
P22	P17	P18	P10	P11		
P23	P21	P19	P13	P12		
P24				P16		

Table 3-14: Extracted factors for example 1, (a) results for SSS1, and (b) results for SSS2

(a) SSS1

Statements	F1 ○	F2 △	F3 ◇	F4 ▭	F5 »
S1	3	2	1	-1	-2
S2	1	-2	3	-2	-3
S3	-2	3	1	-1	-2
S4	0	-2	0	-2	-1
S5	0	-2	1	0	2
S6	3	1	1	0	-1
S7	-2	-2	2	0	-1
S8	1	0	-2	0	-3
S9	-1	-1	-2	0	0
S10	0	0	0	-2	0
S11	2	-3	-1	-1	1
S12	-2	0	-1	3	-2
S13	-1	1	3	2	2
S14	1	-1	0	2	2
S15	-1	0	-1	-3	-2
S16	-3	-1	-2	-1	0
S17	-3	1	-1	0	2
S18	0	0	-2	1	1
S19	0	-1	3	1	-3
S20	1	1	2	1	1
S21	-2	2	-3	2	-1
S22	1	0	-2	-3	2
S23	0	-2	0	3	-1
S24	2	2	2	1	0
S25	3	1	0	2	1
S26	-2	-1	2	0	3
S27	-1	2	-3	3	-2
S28	0	3	2	-2	3
S29	0	3	-1	-3	3
S30	2	2	-1	2	0
S31	1	-3	1	0	1
S32	2	0	0	-2	0
S33	2	-1	0	1	1
S34	-1	-3	-3	1	0
S35	-1	1	1	-1	0
S36	-3	0	0	-1	-1

(b) SSS2

Statements	F1 ◇	F2 △	F3 ○	F4 »	F5 ▭
S1	2	3	2	-3	1
S2	0	-3	1	-2	0
S3	-3	4	-1	1	-1
S4	-2	-2	4	-4	0
S5	0	-3	0	2	-1
S6	3	1	3	-2	0
S7	-1	-2	-3	1	-4
S8	4	0	-2	-2	3
S9	1	-1	-1	3	2
S10	1	1	-2	-1	3
S11	2	-4	2	3	3
S12	1	0	0	-1	-2
S13	-1	2	-2	4	-3
S14	-2	-1	2	2	-2
S15	-1	0	-1	-3	2
S16	-2	-1	-4	-4	0
S17	1	2	-4	2	-1
S18	0	-1	-2	1	2
S19	0	-1	2	-1	-1
S20	0	0	1	0	-2
S21	1	1	-1	-1	-3
S22	-2	1	1	-1	4
S23	3	-2	0	0	-2
S24	-3	3	4	2	-1
S25	4	1	3	1	2
S26	-4	-2	-1	-2	-3
S27	3	1	-3	0	1
S28	-4	4	0	1	1
S29	-1	2	0	-3	4
S30	2	3	1	1	1
S31	-1	-4	1	0	-1
S32	1	0	1	3	1
S33	0	-1	3	4	-4
S34	2	-3	-1	0	0
S35	-1	2	0	0	1
S36	-3	0	-3	-1	0

In the following sub-sections (3.12.2.1(a) and 3.12.2.1(b)), two reliability indicators of Q methodology are discussed and methods for measuring these are proposed. It has been asserted that Q methodology has two abilities, (1) it can extract the attitudes among the participants and (2) it is capable of classifying multiple participants. Each of these capabilities has been evaluated using the results of this example.

(a) Attitude Conservation Potential and Normalised Intercorrelation Vector (NIV)

If we suppose the extracted factors from a Q study are the result of that study, then the stability of these factors (subject to changing the sorting sheet) can be used as an indicator for the reliability of that Q study. As mentioned earlier, if the shape of the sorting sheet does not have a significant impact on the results of a Q study, then each of the factors of the study using SSS1 should be highly correlated with the corresponding factors of the study using SSS2. Table 4 shows the intercorrelation matrix between each factor of study SSS1 and each factor of study SSS2.

Table 3-15: Intercorrelation between factors of SSS1 and SSS2

Correlation		SSS2 F1 ◇	SSS2 F2 △	SSS2 F3 ○	SSS2 F4 »	SSS2 F5 ▭
SSS1	F1 ○	0.389	0.031	**0.786**	0.153	0.282
SSS1	F2 △	-0.076	**0.946**	-0.053	-0.038	0.176
SSS1	F3 ◇	**-0.389**	0.053	0.328	0.114	-0.412
SSS1	F4 ▭	0.404	-0.053	0.000	0.366	**-0.527**
SSS1	F5 »	-0.359	0.038	0.015	**0.374**	0.008

The different colours (or shapes) in Table 3-15 identify the best corresponding factors (ignoring the direction of the sign) within two studies, SSS1 and SSS2. The challenge in finding the best corresponding factors of one study (e.g. SSS1) among the factors of another study (e.g. SSS2) is similar to solving the assignment problems. This means that the Hungarian algorithm, developed by Kuhn (1955) and optimised by Jonker and Volgenant (1986), can be used to find the corresponding factors. So, considering this to be an assignment problem, the Hungarian algorithm works as follows: there are n persons and each person has all the required skills for doing all n tasks (here n=NF=5); but the cost of doing each task by each person is different. The aim is to assign exactly one task to each person (here, exactly one factor of SSS1 to each factor of SSS2) in order to "minimise" the cost of doing all tasks. In this study, the aim is to "maximise" the sum of the correlations (ignoring signs) between all corresponding factors. In doing so, the negative of the absolute value of the intercorrelation matrix is used as the input for the Hungarian algorithm (HA) and the negative of the output of HA will be the best intercorrelation matrix. Indeed, the different colours and shapes in Table 3-13 and Table 3-14 were based on this calculation. As a result, the Intercorrelation Vector (IV) by ignoring signs is as follows:

$$IV = \{0.374, 0.389, 0.527, 0.786, 0.946\} \qquad \text{Eq. (3.10)}$$

It should be noted that since the sorting sheets were different, the maximum possible correlation is not 1, rather, in our example, it is MaxPossCorr=0.9768. So, just to be more accurate the vector IV has been divided over this number. By doing so, the correlations has been normalised between 0 and 1 (ignoring sign).

$$NIV = Normalised\ IV = {}^{IV}/_{0.9768}$$

$$NIV = \{0.383, 0.398, 0.539, 0.805, 0.969\} \qquad \text{Eq. (3.11)}$$

$$Average\,\{NIV\} = 0.62, \quad Min\,\{NIV\} = 0.38, \quad Std.Dev\,\{NIV\} = 0.26$$

As shown in Eq. (3.11), the average correlation between the five extracted factors for the using SSS1 in comparison to SSS2 is 0.62. Hence, it can be said that the factors (or participants' attitudes) of the Q study on SSS1 have been changed by an average of 38% in response to changing the sorting sheet to SSS2. On the other hand, the minimum {NIV} is 0.38. Hence, it can be said that there is at least one factor (attitude) amongst the factors generated using SSS1 which has been changed by 62% when changing the sorting sheet from SSS1 to SSS2. Since the sorting sheet was the only thing which was changed between the two studies (SSS1 and SSS2) in example 1, a hypothesis can be proposed that:

Hypothesis 1: the shape of the soring sheet has an important influence on the explored attitudes of the participants in a Q study.

It should be mentioned that the example 1, only assesses N=2 sorting sheets (SSS1 and SSS2) amongst the several possible sorting sheets that may be chosen by a Q researcher for 36 statements. Hence, it may be possible to have a smaller amount of minimum correlation dependent upon the selection of sorting sheets.

(b) Cluster Conservation Potential (CCP)

As mentioned earlier, it has been claimed that Q methodology is able to categorise its participants it different clusters. Hence, if Q is a reliable method, and if changing the sorting sheet does not change the result of a Q study, then Q should be able to create same cluster when employing different sorting sheets. In this section we aim to find a robust algorithm to calculate the CCP, in such a way that 0≤CCP≤1. The CCP would be 0 when there is no consistency between the exemplifiers of the study SSS1 and those for the study SSS2, and the CCP would be 1 when each (and every) participant which has been chosen as the exemplifier for a factor (e.g. F1) in the study SSS1, has also been chosen as the exemplifier for the corresponding factor (e.g. F3) of that factor in the study SSS2.

The outputs of the Varimax rotation function have been shown in Table 3-16 which contains the rotated loadings of each Q sorts on the extracted factors for both studies using SSS1 and SSS2. Indeed, this table had been used to find the exemplifiers in Table 3-13.

Table 3-16: Rotated loading matrices, (a) SSS1, and (b) SSS2

(a) SSS1

Participants	F1 ○	F2 △	F3 ◇	F4 ▭	F5 »
P1	0.135	**0.668**	-0.090	0.009	-0.056
P2	-0.164	0.307	**-0.636**	0.347	0.043
P3	0.013	-0.059	**0.684**	0.137	0.160
P4	**0.709**	-0.158	0.322	-0.018	0.059
P5	0.110	0.040	0.276	**0.441**	0.368
P6	-0.046	-0.160	-0.316	**0.681**	-0.255
P7	-0.024	0.182	0.370	0.215	-0.164
P8	0.068	-0.324	0.173	0.075	**0.640**
P9	0.384	-0.201	-0.422	-0.312	0.017
P10	0.131	**-0.501**	-0.283	-0.133	-0.402
P11	-0.096	-0.013	0.304	**0.545**	-0.181
P12	0.036	-0.306	-0.104	**-0.632**	0.030
P13	0.064	-0.089	-0.077	**0.626**	0.364
P14	**0.638**	0.163	0.146	-0.013	0.140
P15	0.357	**0.654**	-0.133	0.184	-0.092
P16	**-0.600**	0.190	0.147	0.042	-0.070
P17	-0.304	**0.623**	-0.090	-0.132	-0.054
P18	0.204	0.133	**0.496**	0.031	-0.275
P19	**-0.489**	-0.380	-0.252	-0.007	0.059
P20	-0.403	0.131	-0.094	-0.236	**0.601**
P21	0.164	**-0.711**	-0.187	-0.021	0.009
P22	**-0.525**	-0.052	0.198	0.104	0.178
P23	0.256	0.085	**-0.505**	0.050	-0.358
P24	**0.506**	-0.110	-0.407	0.293	0.002
P25	0.189	0.024	-0.171	-0.042	**0.667**

(B) SSS2

Participants	F1 ◇	F2 △	F3 ○	F4 »	F5 ▭
P1	0.116	**0.599**	0.267	-0.184	0.118
P2	0.350	0.501	-0.455	0.170	0.201
P3	-0.306	-0.182	0.307	0.210	**-0.505**
P4	0.142	-0.398	**0.647**	0.101	-0.009
P5	0.045	-0.007	0.078	**0.644**	-0.232
P6	**0.613**	-0.038	-0.345	0.069	-0.235
P7	-0.190	0.166	0.198	0.041	-0.414
P8	-0.157	-0.233	-0.001	**0.603**	0.210
P9	0.225	-0.133	0.069	-0.152	**0.662**
P10	0.314	-0.350	-0.097	**-0.542**	0.209
P11	0.051	-0.026	0.002	0.009	**-0.550**
P12	-0.250	-0.294	0.062	-0.232	**0.496**
P13	0.241	-0.146	-0.082	**0.636**	-0.184
P14	-0.007	0.090	**0.664**	0.155	0.251
P15	0.227	**0.684**	0.278	0.090	-0.065
P16	-0.412	0.116	-0.322	-0.101	**-0.449**
P17	-0.111	**0.632**	-0.164	-0.189	-0.089
P18	-0.024	0.171	**0.562**	-0.087	-0.269
P19	-0.111	-0.141	**-0.591**	0.010	0.034
P20	**-0.579**	0.073	-0.305	0.237	0.316
P21	0.136	**-0.718**	-0.017	-0.024	0.208
P22	**-0.536**	0.000	-0.253	0.117	-0.111
P23	**0.510**	0.145	0.031	-0.137	0.193
P24	**0.720**	-0.003	-0.010	0.230	0.120
P25	-0.165	0.072	0.070	0.458	0.462

According to Brown (1980, p.222), “*for a loading to be significant at the 0.01 level, it must exceed 2.58(SEr)*”.

$$SLC = Significant\ Loading\ Coefficient = \frac{2.58}{\sqrt{NS}} = 0.43 \qquad \text{Eq. (3.12)}$$

In Table 5, **bold** type is indicative of factor loading of 0.43 and above, participants of the underlined numbers have not been loaded significantly on rotated factors, and double underlines shows the confounded sorts (significant factor loading on more than one of the rotated factors). The significant loadings, shown in bold in Table 3-16, have been replaced by 1 and the non-significant loadings have been replaced by 0 in Table 3-17. Although the non-significant and confounded sorts are not used in estimation of the factors (Watts and Stenner, 2012), it is important to keep their influence in calculating the CCP. Another column is allocated to non-significant loadings. Numbers of a particular confounded sort have been normalised by dividing over the inverse of the 2nd root of the number of significant loadings within that Q sort (for example, here, by dividing 1 over $\sqrt{2} = 0.707$).

Table 3-17: Exemplifiers in matrix of factors, (a) SSS1, and (b) SSS2

(a) SSS1

Participants	F1 ○	F2 △	F3 ◇	F4 ▭	F5 »	not-loaded
P1	0	**1**	0	0	0	0
P2	0	0	**1**	0	0	0
P3	0	0	**1**	0	0	0
P4	**1**	0	0	0	0	0
P5	0	0	0	**1**	0	0
P6	0	0	0	**1**	0	0
P7	0	0	0	0	0	1
P8	0	0	0	0	**1**	0
P9	0	0	0	0	0	1
P10	0	**1**	0	0	0	0
P11	0	0	0	**1**	0	0
P12	0	0	0	**1**	0	0
P13	0	0	0	**1**	0	0
P14	**1**	0	0	0	0	0
P15	0	**1**	0	0	0	0
P16	**1**	0	0	0	0	0
P17	0	**1**	0	0	0	0
P18	0	0	**1**	0	0	0
P19	**1**	0	0	0	0	0
P20	0	0	0	0	**1**	0
P21	0	**1**	0	0	0	0
P22	**1**	0	0	0	0	0
P23	0	0	**1**	0	0	0
P24	**1**	0	0	0	0	0
P25	0	0	0	0	**1**	0

(B) SSS2

Participants	F1 ◇	F2 △	F3 ○	F4 »	F5 ▭	not-loaded
P1	0	**1**	0	0	0	0
P2	0	0.707	0.707	0	0	0
P3	0	0	0	0	**1**	0
P4	0	0	**1**	0	0	0
P5	0	0	0	**1**	0	0
P6	**1**	0	0	0	0	0
P7	0	0	0	0	0	1
P8	0	0	0	**1**	0	0
P9	0	0	0	0	**1**	0
P10	0	0	0	**1**	0	0
P11	0	0	0	0	**1**	0
P12	0	0	0	0	**1**	0
P13	0	0	0	**1**	0	0
P14	0	0	**1**	0	0	0
P15	0	**1**	0	0	0	0
P16	0	0	0	0	**1**	0
P17	0	**1**	0	0	0	0
P18	0	0	**1**	0	0	0
P19	0	0	**1**	0	0	0
P20	**1**	0	0	0	0	0
P21	0	**1**	0	0	0	0
P22	**1**	0	0	0	0	0
P23	**1**	0	0	0	0	0
P24	**1**	0	0	0	0	0
P25	0	0	0	0.707	0.707	0

Then the following equation is used to find the CCP:

$$CCP = \left(\sum_{i=1}^{NF+1=6} E_{F_i} \circ E_{CF_i} \right) \times \frac{1}{NP} \qquad \text{Eq. (3.13)}$$

Where E_{Fi} is the vector of exemplifiers of factor i (in Table 3-17(a)), E_{CFi} is the vector of exemplifiers for the corresponding factor of factor i (in Table 3-17(b)) and "$\circ$" is the dot product operator between these vectors. i=6 is allocated for comparing the columns of non-significant loadings in two studies. By using Eq. (3.13), the CCP value can be calculated as CCP=0.508. So, it can be said that by changing the sorting sheet from SSS1 to SSS2, the composition of participants in clusters has been changed by more than 49%. It should be noted that if we randomly select the exemplifiers for SSS2 we could reach CCP=0.20. As a result CCP=0.508 seems to be really disappointing. So, the second hypothesis can be stated as below:

Hypothesis 2: the shape of the soring sheet has an important influence on the composition of clusters in a Q study.

3.12.2.2 Example 2: Average Agreement Among Participants

Suppose that we repeat Example 1 with 25 other participants (Group 2: P26, P27… P50). The sorting sheets are same (i.e. Figure 3-10) as those used in Example 1. The preference numbers for these individuals over the statements are shown in Table 3-18. The level of consensus among these participants (Group 2) is KW= 0.40, which is higher than that for Group 1 in Example 1 (KW=0.03).

Table 3-18: Preference numbers for 25 other participants (Group 2) over 36 statements

S / P	P26	P27	P28	P29	P30	P31	P32	P33	P34	P35	P36	P37	P38	P39	P40	P41	P42	P43	P44	P45	P46	P47	P48	P49	P50
S1	7	35	31	28	24	33	24	33	12	2	10	28	35	22	29	21	9	34	29	11	10	31	11	24	6
S2	8	16	22	14	16	32	16	12	11	3	17	17	23	14	22	6	21	7	24	15	6	25	12	13	22
S3	30	28	14	36	34	35	25	34	36	20	36	18	28	23	7	30	31	36	32	22	31	34	33	34	27
S4	27	8	16	6	14	16	36	24	10	17	21	25	17	15	10	16	14	27	30	18	4	22	10	33	10
S5	26	36	33	18	35	18	29	31	20	31	30	34	27	5	36	35	29	13	27	26	25	20	35	27	29
S6	19	18	36	21	26	15	35	14	18	25	24	12	20	34	30	8	28	19	34	16	32	18	28	16	20
S7	16	21	8	5	17	17	13	11	1	19	11	31	13	10	5	14	32	21	7	14	19	27	7	35	5
S8	25	24	21	22	36	36	32	36	28	36	26	10	31	30	27	32	25	14	23	21	28	26	13	7	30
S9	23	4	18	2	13	10	15	6	25	5	18	15	25	17	25	11	24	25	6	20	12	36	16	21	1
S10	3	10	23	24	8	13	2	9	2	13	1	23	5	1	6	5	13	15	17	3	16	35	17	10	14
S11	6	1	12	4	7	9	1	7	9	23	14	6	3	2	17	15	2	10	4	1	9	6	6	3	2
S12	9	2	6	11	1	1	7	8	4	10	7	14	6	3	9	12	10	33	15	10	18	2	9	6	3
S13	31	33	25	35	29	26	11	23	30	29	29	30	32	36	8	26	30	32	26	35	27	15	19	20	24
S14	15	17	27	16	4	21	23	28	23	21	27	5	11	7	24	25	17	6	18	17	23	14	24	18	35
S15	29	13	29	33	22	31	8	26	19	15	22	7	12	9	13	2	22	26	21	23	7	23	1	32	28
S16	21	23	5	13	3	22	10	13	21	27	3	24	2	19	16	22	3	9	19	13	11	12	5	17	4
S17	18	25	24	30	18	2	31	25	6	28	34	27	30	35	35	27	27	35	25	33	29	17	27	36	34
S18	32	19	7	34	15	12	21	32	32	34	19	35	34	27	34	24	20	20	22	34	30	29	34	26	25
S19	35	3	34	32	32	29	33	27	33	6	32	32	33	33	26	36	18	23	10	27	17	32	29	9	17
S20	4	22	17	9	25	7	20	5	22	22	5	26	16	12	19	28	19	16	9	25	21	11	15	22	18
S21	11	29	28	25	19	34	27	16	27	35	31	20	15	20	33	31	33	8	31	2	36	28	25	8	23
S22	28	5	26	17	9	11	18	22	29	32	28	3	9	28	28	10	23	17	3	12	33	33	30	15	33
S23	14	31	2	3	30	4	19	3	3	7	6	8	10	4	12	9	4	18	13	29	5	8	32	12	16
S24	22	20	1	19	27	20	3	10	17	11	2	36	26	29	23	13	26	1	35	36	15	5	22	23	8
S25	36	32	30	29	33	23	30	35	35	24	33	4	36	32	31	34	35	31	36	28	22	13	23	19	26
S26	34	34	11	20	31	28	26	30	24	30	35	11	22	26	32	29	34	30	33	31	24	19	36	30	36
S27	10	6	19	1	23	5	9	4	13	16	16	16	14	16	2	7	1	24	16	6	26	4	4	11	7
S28	20	12	13	26	10	8	6	17	26	8	13	21	8	13	11	4	7	28	5	5	8	9	3	2	21
S29	17	26	32	8	2	6	4	20	15	4	25	13	7	21	14	19	12	22	8	24	14	3	21	28	12
S30	33	30	35	31	28	24	34	29	34	33	23	29	18	25	20	33	36	3	28	30	34	30	26	31	32
S31	12	15	15	7	12	14	5	21	31	9	8	22	21	24	18	20	6	11	14	9	2	7	2	1	9
S32	24	14	20	27	20	30	28	19	5	18	15	33	29	31	21	23	11	29	12	32	35	16	18	25	13
S33	1	7	3	15	6	27	14	2	8	14	4	2	1	11	1	1	15	2	20	8	1	24	8	14	15
S34	13	9	9	10	5	3	17	15	14	1	12	9	4	8	4	18	8	12	1	7	3	10	14	5	19
S35	2	11	4	12	21	25	12	1	16	26	9	1	19	18	15	3	5	4	2	4	13	21	20	4	11
S36	5	27	10	23	11	19	22	18	7	12	20	19	24	6	3	17	16	5	11	19	20	1	31	29	31

The exemplifiers, extracted factors and the intercorrelation matrix between these factors are shown in Table 3-19, Table 3-20 and Table 3-21 respectively.

Table 3-19: Exemplifiers for example 2

(a) SSS1

F1 ○	F2 △	F3 ◇	not loaded	confounded
P2	P5	P3		P1
P7	P12	P4		P8
P10	P13	P6		P11
P15	P18	P9		P14
P16	P19	P22		
P17	P20			
P21	P24			
P23				
P25				

(b) SSS2

F1 ○	F2 △	F3 ◇	not loaded	confounded
P7	P12	P1	P5	P2
P10	P19	P3	P6	P13
P15	P20	P4		P16
P17	P24	P8		
P21		P9		
P23		P11		
P25		P14		
		P18		
		P22		

Table 3-20: Extracted factors for example 2, (a) results for SSS1, and (b) results for SSS2

(a) SSS1

Statements	F1 ○	F2 △	F3 ◇
S1	1	-1	-2
S2	0	0	-1
S3	-1	-1	-3
S4	0	-1	0
S5	-3	-2	0
S6	-1	0	-1
S7	1	-1	1
S8	-1	1	-2
S9	2	0	-1
S10	1	2	0
S11	3	3	2
S12	3	1	3
S13	-1	-3	-2
S14	-2	1	0
S15	1	0	-2
S16	2	1	1
S17	-2	-2	1
S18	-2	-3	-1
S19	0	-1	-3
S20	0	-1	1
S21	-2	2	-2
S22	-1	2	-1
S23	0	0	3
S24	1	-3	2
S25	-2	0	-1
S26	-3	-2	0
S27	3	1	3
S28	2	2	1
S29	0	0	2
S30	-3	-2	-3
S31	2	1	1
S32	0	-2	0
S33	2	3	0
S34	1	2	2
S35	0	3	0
S36	-1	0	2

(b) SSS2

Statements	F1 ○	F2 △	F3 ◇
S1	3	0	-1
S2	0	1	1
S3	-1	-2	-4
S4	0	-1	0
S5	-3	-2	-1
S6	-1	0	-1
S7	1	0	2
S8	-2	1	-2
S9	3	0	0
S10	1	2	4
S11	4	4	3
S12	2	1	3
S13	-1	-4	-3
S14	-1	1	0
S15	0	-1	-1
S16	1	1	1
S17	-2	-3	-1
S18	-2	-3	-2
S19	0	-1	-3
S20	0	-1	2
S21	-3	3	-1
S22	-3	2	-2
S23	1	-1	3
S24	1	-4	1
S25	-2	-1	-4
S26	-4	-2	-2
S27	2	1	1
S28	2	3	0
S29	1	0	0
S30	-4	-2	-3
S31	4	2	1
S32	-1	-3	0
S33	2	2	4
S34	3	3	1
S35	0	4	2
S36	-1	0	2

Table 3-21: Intercorrelation between factors of SSS1 and SSS2

Correlation		SSS2 F1 ○	SSS2 F2 △	SSS2 F3 ◇
SSS1	F1 ○	**0.908**	0.465	0.633
	F2 △	0.420	**0.954**	0.496
	F3 ◇	0.481	0.221	**0.717**

By employing the method used in Example 1, NIV, average {NIV}, min {NIV} and CCP can be obtained as follow:

$$NIV = Normalised\ IV = {}^{IV}/_{0.9768}$$
$$NIV = \{0.734, 0.930, 0.977\}$$
$$\overline{NIV} = 0.88, \quad Min\{NIV\} = 0.73, \quad Std.Dev\{NIV\} = 0.13$$
$$CCP = 0.810 \qquad \text{Eq. (3.14)}$$

Clearly, results of this example are completely different from what we obtained in Example 1. As seen from Eq. (3.14) this example provides a strong confirmation of the capabilities of Q. The average correlation between factors is 0.89, meaning that the attitudes of participants have changed by only 11% when changing the sorting sheet from SSS1 to SSS2. Also, the CCP coefficient is 0.838, indicating that the composition of participants in the clusters have changed by almost 16%.

Comparison between the Example 1 and Example 2, indicates that the level of consensus among the study's participants (KW) is playing an important role in reliability of a Q study, since the KW value is the only variable which was changed from Example 1 to Example 2. Hence, two questions may arise that:

Does the shape of a SSS influence the results of a Q study? And if yes, does KW correlate negatively with this influence? (**Question 1**)

Does the shape of a SSS influence the composition of the participants in the groups? And if yes, does KW correlate negatively with this influence? **(Question 2)**

If it can be proved that the amount of KW has a significant influence on the minimum and average correlations among the extracted factors when comparing two studies which have same NP, NS and preference matrix, then it would be possible to claim that the reliability of a Q study depends on the average agreement of the participants in a Q study; or KW. It should be emphasised again that the aim of section 3.12 only is to discuss the reliability of a Q study with respect to the sorting sheet; i.e. to the extent to which a Q researcher can extract the same factors should we change the SSS employed in the study.

3.12.3 Results of Simulation

The simulated samples (see section 3.12.1) were exported to SPSS for further analysis. Table 3-22 shows the correlation coefficients between all independent variables in rows and all dependent variables in columns. This table addresses two above mentioned research questions. As indicated in Table 3-22, all 'average NIV' (Normalised Inter-correlation Vector), 'minimum NIV', 'average CCP' (Clustering Potential) and 'minimum CCP' are strongly correlated with KW. This means that when the consensus between the participants about the topic is small, changing the distribution sheet to another one will change both the extracted factors (attitudes) and the composition of the participants in different factors. Clearly, this challenges the reliability of Q methodology, since the participants' attitude should not be changed by simply changing the sorting sheet. As shown in Table 3-22, the influence of other independent variables on the dependant variables is not large enough. The impact of each variable will be discussed in more detail in the next sections.

Table 3-22: Correlation between dependent and independent variables (N=13475)

Correlations		NF	Average {NIV}[a]	Minimum {NIV}	StdDev {NIV}	Average {CCP}	Minimum {CCP}	StdDev{CCP}
KW	Pearson Correlation	**-0.836****	**0.914****	**0.906****	**-0.900****	**0.898****	**0.906****	**-0.900****
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NS	Pearson Correlation	0.182**	-0.071**	-0.092**	0.078**	0.111**	0.132**	-0.143**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NP	Pearson Correlation	0.149**	-0.039**	-0.033**	-0.015	-0.078**	-0.042**	0.023**
	Sig. (2-tailed)	0.000	0.000	0.000	0.088	0.000	0.000	0.008
NC	Pearson Correlation	-0.005	0.027**	0.014	-0.009	0.024**	0.014	0.001
	Sig. (2-tailed)	0.598	0.002	0.093	0.322	0.006	0.115	0.909
Deviation of SSS	Pearson Correlation	-0.017*	0.027**	0.019*	-0.012	0.020*	0.004	0.020*
	Sig. (2-tailed)	0.048	0.001	0.028	0.150	0.023	0.654	0.022
Slope	Pearson Correlation	0.007	-0.026**	-0.013	0.003	-0.018*	-0.017*	0.027**
	Sig. (2-tailed)	0.445	0.003	0.144	0.735	0.039	0.046	0.002

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

a. Average {NIV} is the average between the averages of different comparisons. Minimum {NIV} is the average between the minimums of different comparisons and finally Std. Dev {NIV} is the averages between the standard deviations of different comparisons.

3.12.3.1 Effect of the Consensus (KW) on Reliability

Figure 3-11 shows the effect of the KW on two-fold capabilities of the Q methodology, i.e. attitude finding (represented by NIV) and clustering (represented by CCP). The reliability of the Q methodology decreases rapidly by decreasing the consensus of the participants. Two points in each graph have been added to represent examples 1 and 2. Figure 3-12 shows the relationship between the average {NIV} and minimum {NIV} for different KW values. When KW≥0.5, since there is only one factor (one attitude) to explain the 50% of variation, the average and minimum {NIV} are equal. So, there is a linear relationship in that part of Figure 3-12. Although for a specific KW (≤0.4) both the variables (i.e. minimum {NIV} and average {NIV}) change in a wide range, there is a harmonious relation between these variables and KW, which again confirms that the level of consensus between participants of Q study is the main determinants of the reliability of Q methodology with respect to the sorting sheet.

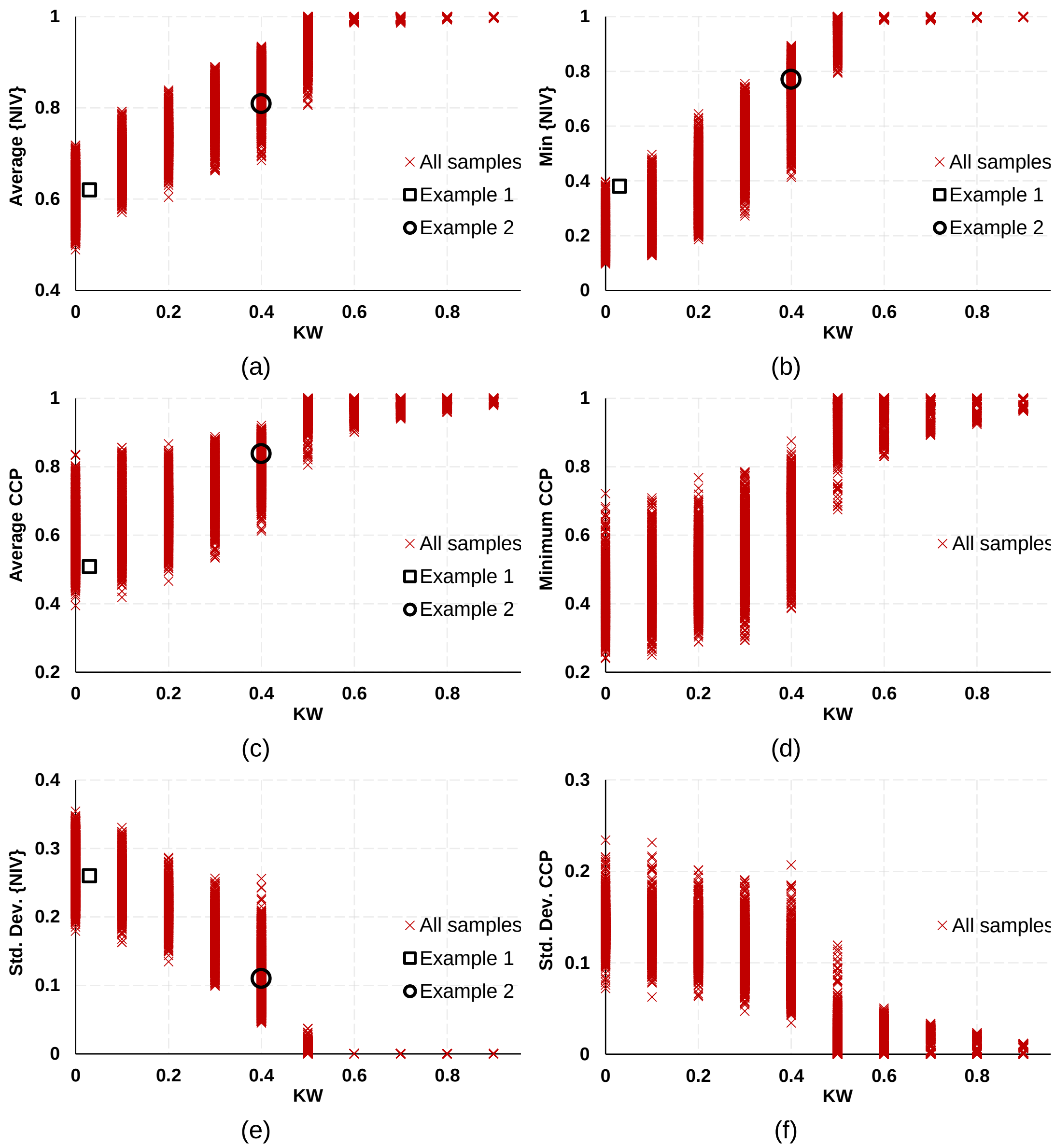


Figure 3-11: Effect of KW on reliability of the Q methodology

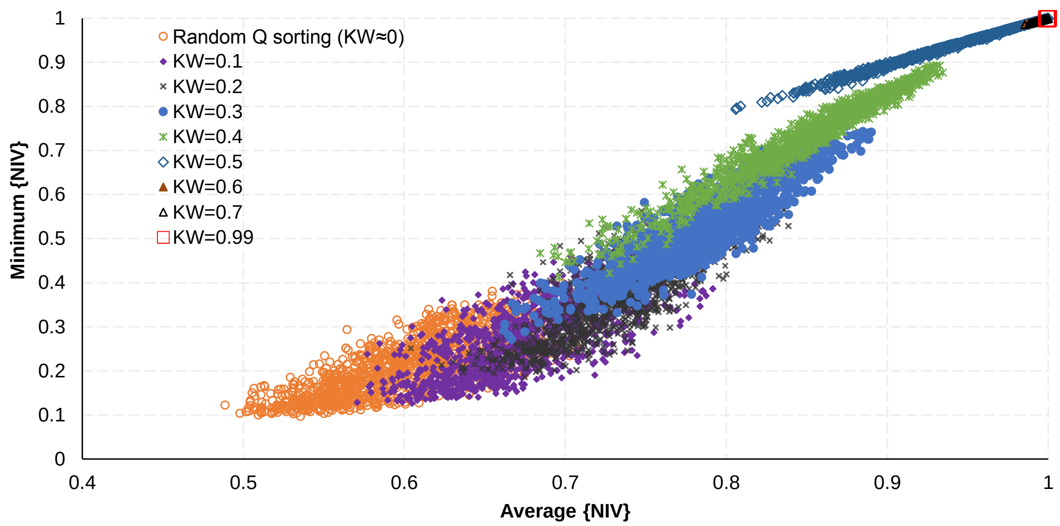


Figure 3-12: Relationship between average NIV and minimum NIV (N=13475)

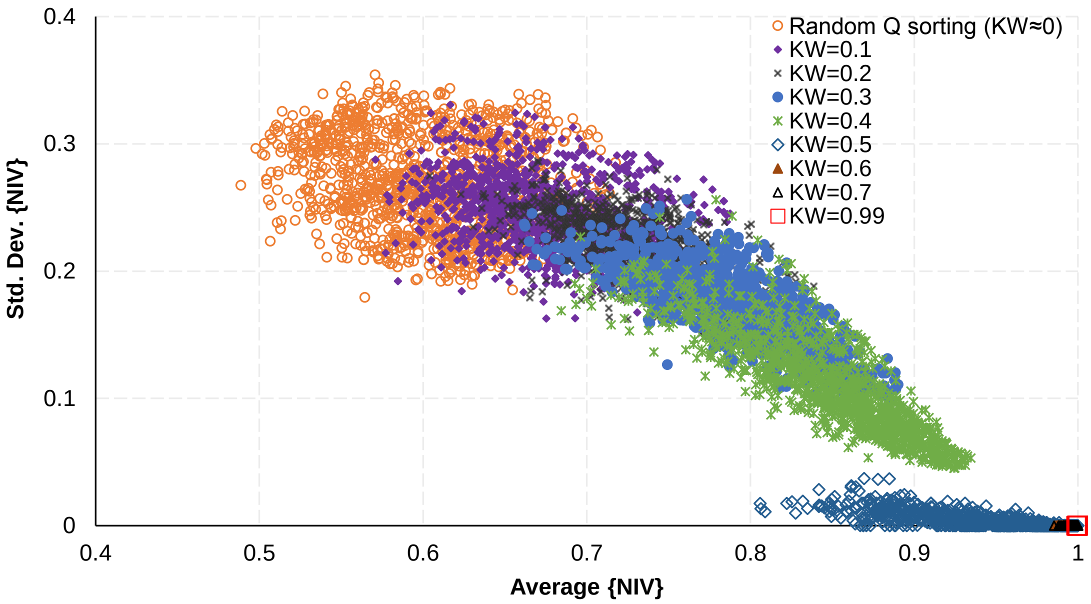


Figure 3-13: Relationship between the average and standard deviation of NIV (N=13475)

The capability of Q in terms of attitude exploration (NIV) and cluster conservation (CCP) becomes more disappointing once we consider the correlation coefficients between KW and both the standard deviation [NIV] and standard deviation [CCP] in Table 3-22 (correlation= -0.900). As shown in Figure 3-13, the high negative correlation between KW and standard deviation [NIV] demonstrates that when the value of KW is small (and consequently when there is small intercorrelation coefficients between the extracted factors as shown in Figure 3-12), the standard deviation of [NIV] grows rapidly and this makes it possible to have at least one very small correlation coefficient (near to zero) between the corresponding factors of two Q studies with the same NS, NP and preference matrix but different sorting sheets.

Figure 3-14 shows the effect of KW on the reliability of Q methodology in a small range of samples. As seen from this figure, the shape of the sorting sheet (by changing the NC: number of columns) does not change the overall reliability of Q methodology for either indicators (average [NIV] or average [CCP]). Also, comparing the Figure 3-14(a) with Figure 3-14(c) and (or similarly comparing Figure 3-14(b) with Figure 3-14(d)) indicates that the number of statements (NS) and number of participants (NP) do not have a meaningful influence on these reliability indicators.

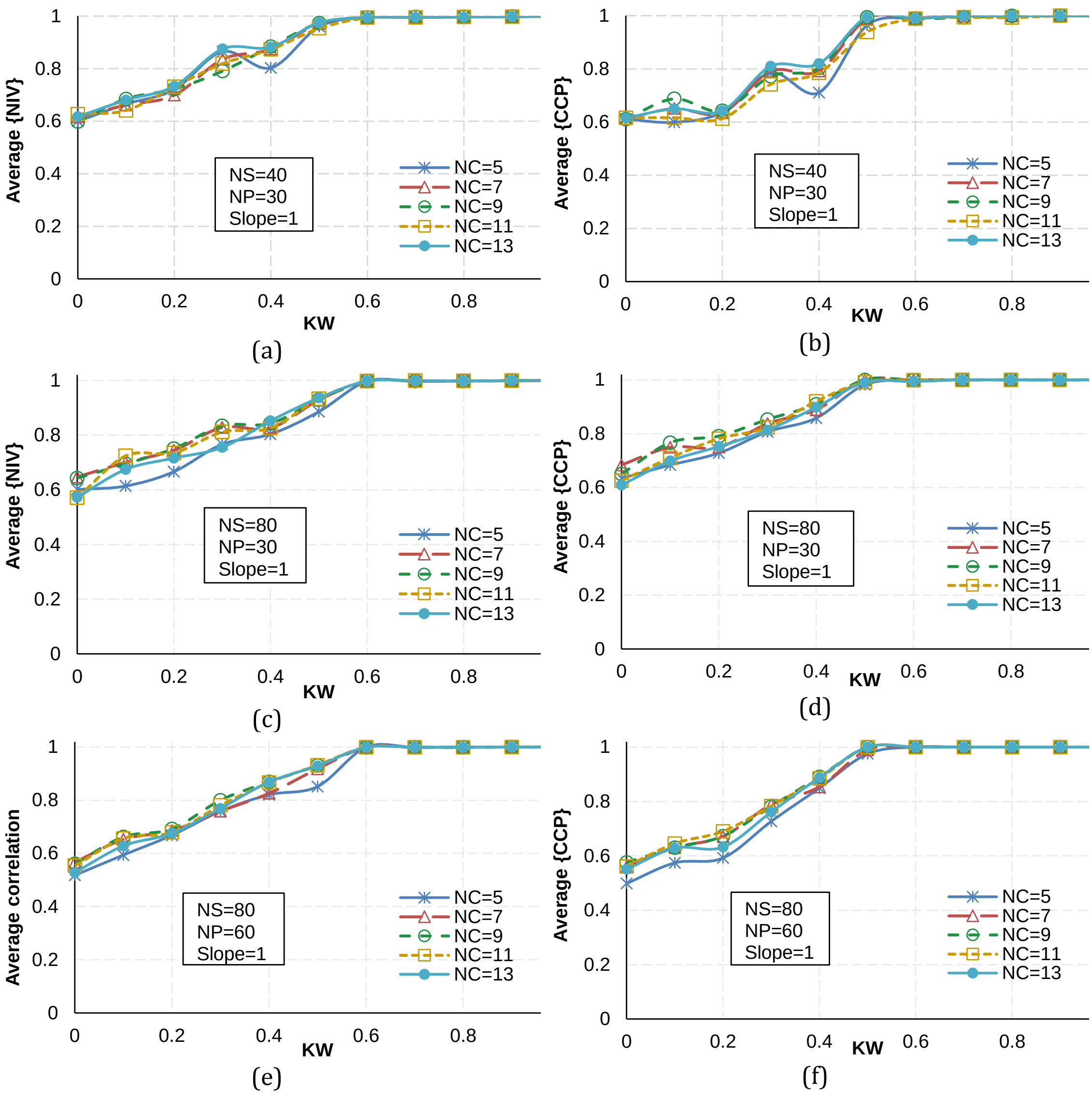


Figure 3-14: Effect of KW on average [NIV] and average CCP

3.12.3.2 Effect of the Sorting Sheet on Reliability

Figure 3-15 shows the effect of the standard deviation of the sorting sheet on average [NIV] for different values of KW. It can be concluded that changing the sorting sheet to another one in itself does not change the results of a Q study.

Rather, if the consensus level among participants (KW) is not high enough, using different sorting sheets will produce different results (factors or attitudes). This figure has one very important implication. As we know Q is a data reduction method, most of literature suggest keeping 50% of the total variance. When the level of consensus among participants (KW) is low, results are volatile since the analysis of the data obtained from different sorting sheets will keep different parts of the collected data.

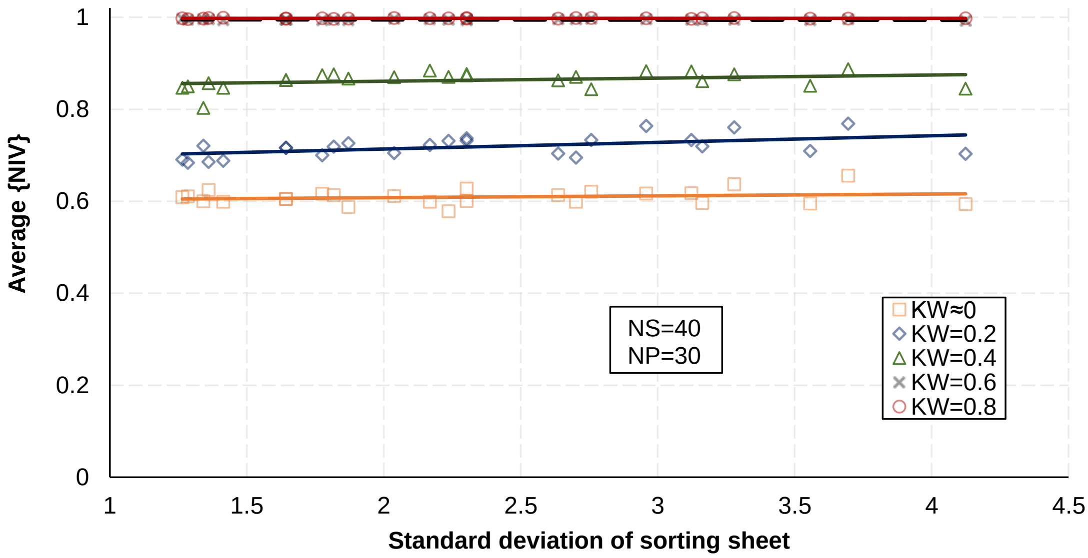


Figure 3-15: Effect of the standard deviation of the sorting sheet on average [NIV] for different KW

3.12.3.3 Effect of the Number of Statements (NS)

The correlation between NS and average [NIV] is -0.071 and the correlation between NS and average [CCP] is +0.111. As a result, increasing the number of statements, increases the reliability of the Q by a small extent in terms of the clustering of participants, but decreases the reliability of the extracted attitudes. Figure 3-16 shows this relationship when KW=0.2. This can help us to better understand the influence of both NS and KW on the reliability of the Q methodology. It should be noted that although the Table 3-22 shows a significant correlation between KW and both the average [NIV] and average [CCP], since there is an overlap between the samples of two the continuous NS (e.g. NS1=40 and NS2=50) in Figure 3-16, increasing NS does not increase the average [CCP] nor decrease the average [NIV] in all situations. In fact, the correlation coefficients show an average trend for all samples.

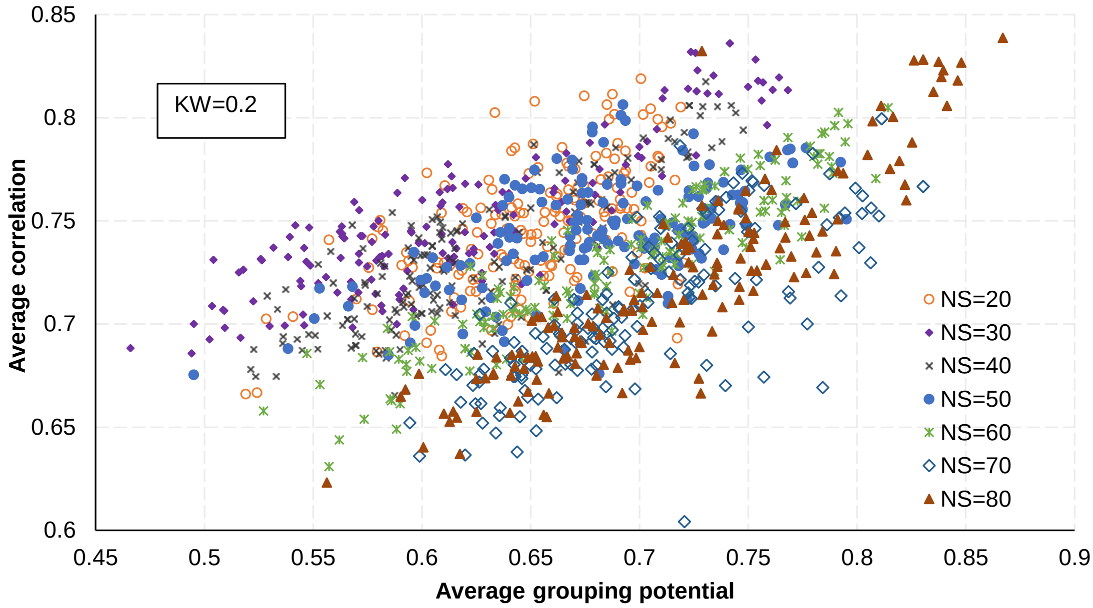


Figure 3-16: Influence of NS on the average NIV and average CCP, KW=0.2 (N=1225)

3.12.3.4 Effect of the Number of Participants

As shown in Table 3-22, NP is negatively correlated with both capabilities of Q methodology. In other words, increasing the number of participants in a Q study will decrease both reliability indicators of Q methodology (i.e. attitude finding and participant clustering). Correlation coefficients are -0.04 and -0.08 respectively. Figure 3-17 shows their relationships in some part of the simulated samples. Comparing the Figure 3-17(a) with Figure 3-17 (c) (or Figure 3-17(b) with Figure Figure 3-17(d)) highlights the influential role that KW plays in increasing or decreasing the reliability of Q. Also, it can be seen again that the shape of the sorting sheet itself does not influence the reliability of a Q study. An interesting conclusion from this figure is that when the consensus level among the study participants is more than KW>0.4, increasing the number of participants increases the reliability of the Q study. Hence, although Q works well with small number of participants, this does not mean that it cannot be used to analyse the attitude a large number of participants. Indeed, Q's ability in finding the attitudes of a small group of people must be seen as advantage of this method, not as a limitation.

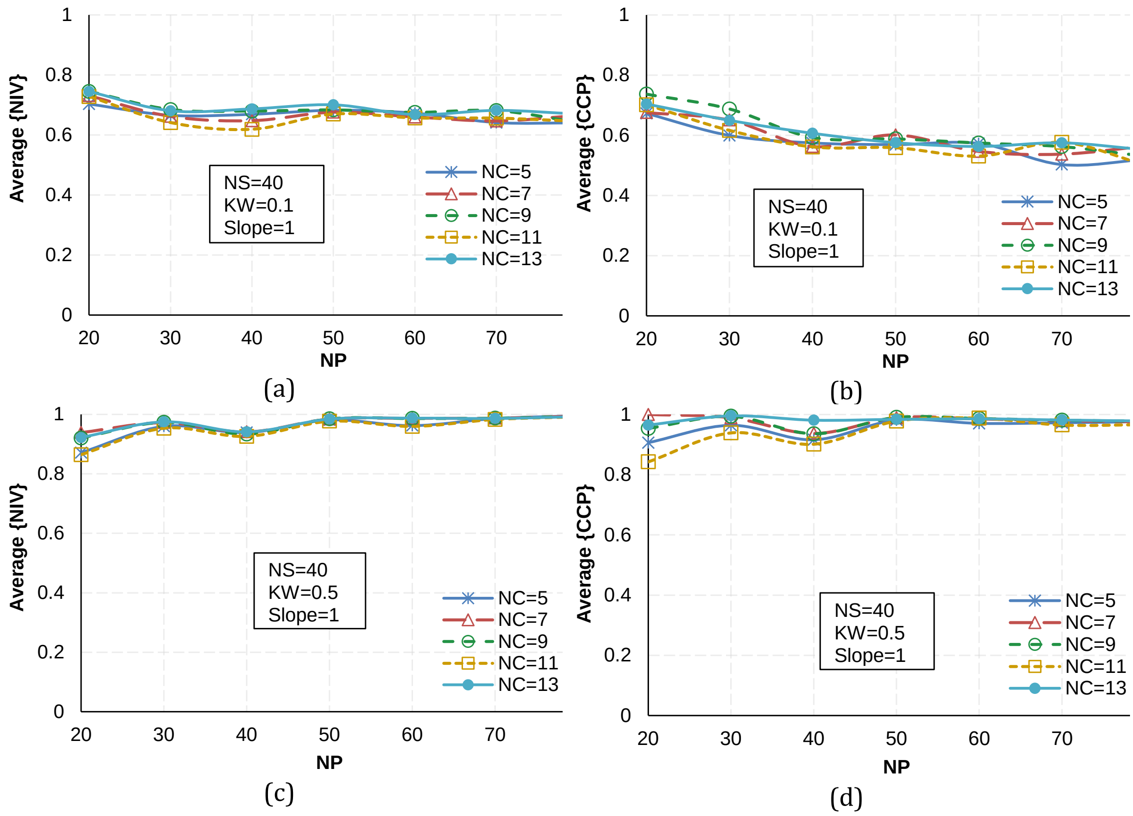


Figure 3-17: Influence of NP on average NIV and average CCP

3.12.4 Discussion

The results of the simulation show that the reliability of a Q methodology is strongly correlated with the level of consensus among the participants. In comparison to KW, other independent variables have very limited impact on [NIV] and [CCP]. The results of the Q methodology is 100% reliable when KW>0.5, since in this situation changes in the sorting sheet does not have any influence on the extracted factors and the composition of the groups. As discussed in section 3.11.5, the average Spearman's correlation between the Q sorts of a Q study is usually between ρ=0.20 and ρ=0.50. Equation (7) shows the relationship between KW and ρ.

$$KW = \frac{\rho \times (NP - 1) + 1}{NP} \qquad \text{Eq. (3.15)}$$

By using this equation, the average KW for the 36 Q studies outlined in Table 3-8 is KW=0.378 (σ=0.143). It may be claimed that the complete reliability (100%) of Q methodology for KW>0.5 is not useful in reality; as in 30 studies (out of 36) the KW value is less than 0.50. But, if we consider the range of reliability of simulated samples (when KW<0.5), the reliability of Q methodology in terms of attitude finding and clustering is 71% and 73%, respectively. As a result, it can be said that although, like other methods, Q methodology is not 100% reliable, its results are extensively reliable. In order to prove this hypothesis, we repeated the same process, discussed in methodology section, but this time, those independent variables, i.e. NP (number of participants), NS (number of statements), Var (explained variance), and KW (consensus level between participants) were same to the values which are used by scholar of 36 Q studies in Table 3-8. In other words, the aim of this section is to find the reliability of empirical Q studies which have used a specific sorting sheet, i.e. to what extent these Q studies could obtain same factors and same clusters if they had used another sorting sheet. Results show that the average reliability of 36 Q studies, in terms of attitude finding and participant clustering, is about 84% and 86%. It can be concluded that the average consensus among the Q participants is usually large enough to guarantee that the Q methodology can extract the same factors and find the same clusters when employing different forced distribution sheets.

The literature review shows that Q researchers have explored the significant role of KW. Exel and Graaf (2005, p.3) state that "*an important notion behind Q methodology is that only a limited number of distinct viewpoints exist on any topic … [and] any well-structured Q sample, containing the wide range of existing opinions on the topic, will reveal these perspectives*". The phrase "*a limited number of distinct* *viewpoints*" clearly is about the shared opinions or the level of consensus among the participants (KW) with respect to the topic of the study. However, it seems that the literature has remained silent with respect to the influence of this parameter on the reliability of the results of the Q methodology.

By providing an example, Brown (1980, p.288-9) argues that the forced distribution sheet does not bias the Q methodology. However, in practice, he has provided a sorting matrix with KW>0.90. Results of this chapter shows that when KW>0.50 results of the Q methodology is 100% reliable (in explaining 50% of the variance) and changing the distribution sheet will not change the results of the study; the main problem is that of the studies reviewed Table 3-8, none had reached a value for KW greater than 0.90. Indeed KW>0.9 is more related to the objectivity rather than subjectivity. This study addressed this issue through considering the effect of KW on results and reliability of methodology. However, in the next section, three measures have been suggested which can further increase the reliability of Q methodology.

3.13 Three Suggestions for Q Researchers

3.13.1 Using Spearman Correlation Instead of Pearson Correlation

Brown (1980, p.206) argues that that the collected data from each participant is not "ordinal" data, rather it is "interval" data. Brown does not provide any justification for this argument except that participants have too many options to sort Q sample on the sorting sheet. Clearly, giving too many sorting options to participants will not change the nature of the collected data. Hence, despite using the scores on the distribution sheet, the collected data from a participant of a Q study is an "ordinal data" and is not rated/interval data. As a result, it is better to use the Spearman's 'rank' correlation (rho) instead of Pearson correlation; since it is more consistent with the nature of the collected data. We applied the sample methodology on the data (when KW<0.5) but with this small change, i.e. after finding the Q sorting matrix, Spearman's rho correlation was used and this correlation matrix was passed to Principle Component Analysis and Varimax Rotation functions. Comparison between results shows that replacing the Person correlation with Spearman Correlation will increase both reliability indicators of Q methodology. As shown in Figure 12, reliability of Q in terms of attitude finding and participant clustering will increase by 2.43% and 3.85% respectively.

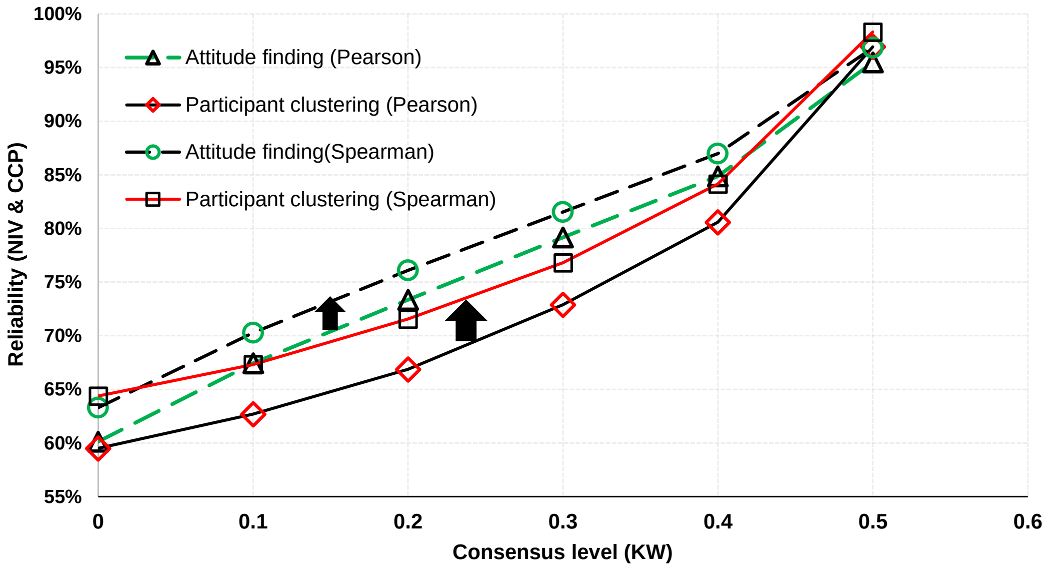


Figure 3-18: Using the Spearman correlation instead of the Pearson correlation increases the reliability of the Q methodology

3.13.2 Using a Constant Measurement at Different Steps

In a Q factor analysis, when the researcher is deriving the final factor estimate, the scale of the collected data is changed. For example Watts and Stenner (2012, p.133) states "our example study used an 11-point or +5 to -5 distribution. For the purpose of this calculation [deriving the final factor estimate], however, the various rankings in the distributions are simply scored from 11 down to 1; a score of 11 equates to a ranking +5, 10 to a ranking of +4, and so on". Although Brown (1980, p.264) argues that this re-scaling does not change the mean and standard deviation of Q-sort distribution, it has not been mentioned at all why this re-scaling was necessary itself. In fact, not only it is not required, but also it makes the analysis wrong when the loading is negative. Most likely this is why Donner (2001b, p.33) found it very difficult to understand negative loads and did not use those negative loadings in estimating the final factors. By having a constant measurement (and consequently by not having an unnecessary step) negative loadings can be considered in factor estimation which in turn will increase the reliability of Q methodology through keeping the influences of high negative loadings in factor estimation.

3.13.3 Correct Interpretation

In a Q sorting process (on a forced distribution sheet), participants are not allowed to choose their “zero” points. According to Carifio and Perla (2007, p.111), “*an arbitrary zero point (not a true zero point)”* is the first requirement for a data to be interval. This is another reason why the collected data in a Q study is ordinal. In Q methodology, the participant “must” accept that the middle column is the zero point. As a result, the only thing which can be said about the collected data is that they show the priority of the participant regarding the proposed Q sample, not their agreement/disagreement.

However, in the interpretation phase and explaining the factors (or discourses), almost all Q researchers have interpreted the results as “agree” and “disagree” not as “higher priority” and “lower priority”. This kind of interpretation is not based on an “arbitrary zero point”, rather it is based on a “true zero point” which is not consistent with the nature of the collected data from a forced distribution sheet.

3.14 Conclusion

Drawing upon the aims and questions of this research study, discussed in Chapter 1, the effectiveness of the both qualitative and quantitative approaches were evaluated. It was concluded that the combination of both approaches, known as mixed method, is the best approach to address the research questions. The qualitative phase of the research involves a multiple case study analysis, interviews and Q sorting and the quantitative phase includes the Q factor analysis. Considering the main themes discussed in literature (see Chapter 2), two sets of criteria were used to select two case study cities, Belfast and Cambridge.

In order to evaluate the effectiveness of the Q methodology for the aim of this research, 36 peer-reviewed articles were analysed. The initial findings showed that there is a lack of knowledge regarding the relationships between different variables which influence the results of a Q study. Hence, a numerical approach was used to simulate the process of Q methodology and track the effect of each variable on the results and reliability of the Q methodology.

Q methodology is an approach for data reduction as well as data clustering. With regard to data reduction, it is desirable to draw a conclusion from most of the available data and consequently to ignore as little data as possible, therefore increasing the explained variance (*Var*) is one of the desired aims. Most of the literature has suggested that consideration should be given to *Var=50%* as the minimum acceptable amount. On the other hand, Q as a data clustering method aims at finding a reasonable number of attitudes (factors) among the participants. The literature showed that 3, 4 or 5 factor solutions are the best choices. The more factors the smaller average of eigenvalues of factors. However, these two aims (Q as data reduction / clustering method) do not work in the same way i.e. reducing the number of factors decreases the explained variance of the study. As a result it is necessary for the researcher to think carefully about these aims during the research design process.

Findings of this chapter show that as long as Q researchers can explain an acceptable amount of the variance by a reasonable number of factors, increasing the number of participants can increase the reliability of the research. Because the factors of a Q study revealed from a small number of participants is more sensitive to change by adding another participant to the P-set. To summerise, Q methodology can be used by small number of participants, however, it does not mean that it is not suitable to be used by a large number of participants. In this research, Q statements are generated using the data collected in qualitative phase of the research as explained in Chapter 4. Researcher do not put any cap for number of participants. Q sorts will be analysed regularly by the researcher when a new Q sort is submitted by a participant. When the explained variance for the study (in each case study area) reached to 50% by four factors, no further invitation email is sent to participants, though all Q sorts from previous invitation emails is considered in analysis.

However, it was found that there is no clear cut rule to calculate the number of participants since it depends on other variables including *NS*, *Var*, expected or desired *NF*, and the level of consensus between participants about the topic (ρ). Hence, the best suggestion for each research study, with respect to the number of participants, can be made by its researcher considering the context of the research. Findings from the literature review in Chapter 2 shows that the implementation of the transport policies is a complex process and there are different attitudes towards the effective and efficient approach to adapt the road transport sector to climate change impacts. Hence, although there are many variables which can influence the outcome of the policy implementation, it is required to reduce the number of statements as many as possible in order to extract a reasonable number of factors from Q methodology.

By using the 13,475 simulated samples, two capabilities of Q methodology (Q as participant clustering method, and Q as attitude finder method) were evaluated, subject to changing the shape of the sorting sheet. Results shows that the reliability of the Q methodology is strongly correlated with the level of consensus among the study participants. Results of empirical studies shows that the average consensus among the Q participants usually is large enough to guarantee that all Q studies can extract same factors and same clusters by employing different forced distribution sheets. On the other hand, as we know Q is a data reduction method, most of literature suggest keeping 50% of the total variance. When the level of consensus among participants is very low ($KW<0.2$), results can be volatile since the analysis of the data obtained from different sorting sheets will keep different parts of the collected data. Hence, it is recommended that the researchers should pay particular attention to the level of consensus (KW) among the participants.

Finding of Monte Carlo simulation shows that the shape of a forced distribution sheet does not change the result of a Q study. Hence, this study will use a sorting sheet with less number of columns to give the study participants a manageable scoring scale. Results from a pilot Q study in University of Ulster showed that a sorting sheet 7 columns is considered a suitable scoring sheet by participants.

Although analysis of empirical studies shows that the Q methodology is a reliable method (with more than 84% reliability level), using the findings of this chapter, this thesis will use some more measures which can increase the reliability of Q methodology. One important and straightforward measure which can be implemented is replacing the Pearson correlation with the Spearman Correlation. Although the improvement of reliability is not high (about 3%), it is more justifiable to apply a 'rank correlation' function to a ranked data. Also, Q researchers which are using forced distribution sheet should avoid making interpretation about agreement or disagreement of statement by the study participants. Rather the interpretation should be regarding the priority of the participants about the Q sample.

Chapter 4 - Interview Findings

4.1 Introduction

This chapter presents the results of interviews with stakeholders in two case study areas: Belfast and Cambridge. As detailed below, 26 individuals from public organisations at local and regional levels, academia, NGOs and interest groups participated in discussions. Participants are recruited using a combination of web search and snowball sampling technique; i.e. respondents were asked to introduce others which can contribute to this research. Table 4-1 shows the split of 26 participants between Belfast and Cambridge.

Table 4-1: In-depth interview participants

Case study city	Organisation	Number
Belfast	*University of Ulster*	1
	Belfast city council	1
	Northern Ireland Environment Link (NIEL)	1
	Rivers Agency	1
	SW Consultancy	1
	Atkins	1
	Charles Tennant & Co (NI)	1
	Friends of the Earth	1
	Freight Transport	1
	NI Cycling Initiatives	1
	Institute of Civil Engineering	1
Cambridge	*Cambridge City Council*	3 (including 2 councilors)
	Cambridge Centre for Climate Change	3
	Cambridgeshire County Council	2
	University of Cambridge	3
	Interest group(former politicians)	2
	Cambridge Cycling Campaign	1
	Travel for Cambridgeshire Partnership	1

As outlined in the first chapter, the aim of collecting the qualitative data as a part of a Q methodological research is that, firstly it evaluates the relevance and importance of the factors discussed in the literature in the process of implementation of climate change adaptation policies for the road transport sector, and secondly it explores those factors which were not discussed in the reviewed literature. Findings from this chapter along with the findings from the literature review about the barriers of climate change adaptation process (see chapter 2) will be the starting point for generating the Q set (Q sample or Q statements). Then the generated Q set will be used to evaluate the attitudes of stakeholders regarding the effectiveness of governance arrangement models on the implementation of climate change adaptation policies in road transport sector. Findings from Q methodology are reflected in Chapter 5.

As discussed in the following sections of this chapter, regardless of the level of the importance and emphasis of participants, almost all factors, which were highlighted by study participants in the two case studies, are around some common themes. This chapter aims to discuss these themes and their surrounding factors emphasised by participants. However, since these factors will be used to collect and analyse Q methodology data in Belfast and Cambridge, this chapter also highlights the importance of those factors for each case study area to enable the research in the evaluation of the findings from Q methodology. Therefore, in order to avoid duplicating the discussion about those factors, the following sections present the main obstacles and opportunities for improving the process of climate change adaptation and sustainable transport implementation and delivery at city level in two case study areas. All these factors have been categorised in 5 inter-connected groups including governance and policy barriers, institutional barriers, scientific barriers, political barriers and economic barriers. This chapter also provides a qualitative comparison about the differences between attitudes of stakeholders regarding those issues in two case study areas. It should be noted that the order of different themes is based on the order of the policy cycle, and does not reflect the importance of those themes.

4.2 Climate Change Risks to Road Transport System

4.2.1 Impacts of Climate Change on Road Transport (Belfast & Cambridge)

Flooding, extreme weather conditions, more precipitation and hotter summers were perceived to be the most important direct impacts of climate change in Belfast and Cambridge. 7 participants (out of 26) referred me to the Climate Change Risk Assessment (CCRA, 2012) developed by DEFRA to address the question about the current and future impacts of climate change in their region. It can be argued that CCRA plays an influential role in raising the awareness of stakeholders about climate change adaptation. However, participants from Belfast and Cambridge had different attitudes toward the indirect impacts of climate change in road transport. Although according to the UKCIP (2009) projections east of England will experience much less change in rain pattern in comparison to other parts of the UK, but the main focus of the participants in Cambridge was mostly on extreme weather conditions and its indirect impacts on the modal shift from sustainable modes of transport such as walking and especially cycling to private car use. While in Belfast, the concerns of the majority of participants were mostly related to the flooding and increasing the cost of road maintenance.

> *"Our adaptation challenges are how to deal with potentially increased rainfall. … There is distinct reduction in the number of cyclists and increase in the number of cars on road when it is raining. So, if you get climate change in the sense of more rain that might reduce the numbers of cyclists".*
>
> Respondent from University of Cambridge

> *"So what is the effect of water saturation on roads and things like that over a long winter period? You are getting that every year. We are going to need to invest more money in road maintenance at the same time we are trying to spend more money on public transport."*
>
> Respondent from Northern Ireland Environment Link, Belfast

The results show that effects of increasing temperature on road infrastructure is more significant in Cambridge than it is in Belfast. The majority of participants in Cambridge highlighted the effects of warmer summers on road infrastructure such as road buckling, pot holes, subsidence and heave. Two participants even considered it to be the most significant impact of climate change in Cambridge area. However the modal shift was not recognised to be a serious consequence from hot summers. It was emphasised that air temperature in Cambridge “might get up to 30 degrees”, hence it will not be hot enough to reduce cycling rate in Cambridge. Participants in Belfast did not recognize the high temperature as a significant impact of the climate change. Only one participant emphasised the role of high temperature on discomfort of public transport users.

> *“In the discussions we had in city council, we’ve looked at the issue of the surface of roadways as being probably the most important one and then secondly at the flooding of roadways”.*
>
> Respondent from Cambridge Centre for Climate Change

Participants from both case study areas mentioned the sea level rise as a possible impact of climate change in their areas. However, it was argued that this impact may not be seen in near future. In Belfast, as a coastal city, emphasis of participants was on the association between sea level and high water table. It was highlighted that, with a rise in the sea level, on occurrence of heavy rain there is very little space between the ground level and high water table which consequently can increase the risk of flooding. A participant in Cambridge highlighted the same issue in Cambridge case study. It was mentioned that, since Cambridge is a low lying area (almost 6 meters above sea level), sea level rise can be considered a major issue in managing the surface runoff.

4.2.2 Progress of Climate Change Adaptation

Findings show that the progress of implementation and delivery of climate change adaptation policies in Belfast and Cambridge has considerable difference. Although none of cities have made a perfect progress towards adapting their road transport sector to climate change impacts, findings shows that Cambridge has had a considerably better progress in different stages of the policy cycle. This section summarises the effectiveness of the implementation process of climate change adaptation policies in Belfast and Cambridge.

4.2.2.1 How Belfast's Road Transport System is Adapted to Climate Change?

Almost all of participants in Belfast explicitly stated that the adapting road transport sector to the impacts of climate change was not effective.

> *"It could be very critical, I have seen no evidence of a road design to accommodate the climate change."*
>
> Respondent from Rivers Agency, Belfast

The dominant view in Belfast was that the existing adaptation activities and policy measures in road transport sector is a reaction to the climate change impacts rather than reducing the exposure to future risks (proactive adaptation). Although participants related the reactive climate change adaptation to the uncertainty of climate change and its negative impacts in determining appropriate measures and investments, they argued that developing a long-term integrated thinking process for climate change adaptation and transport planning can be an appropriate approach to address the climate change and deal with its uncertainty.

> *"The perception of engineers is buildings and controlling it. … We would build higher and higher coastal defenses to stop sea level rises. That is controlling area; it is not achievable, it is not sustainable."*
>
> Respondent from SW Consultancy, Belfast

> *"Belfast … spent over 105 million Pounds on a new tunnel to divert a lot of that strong water away …. But that still hasn't solved some of the problems in East and South Belfast where there are a lot of climate change impacts".*
>
> Respondent from University of Ulster, Belfast

As we will see in section 4.6, participants perceived that the lack of proper policy documents impedes the effective delivery of climate change adaptation policies. However, there were a few statements made during the interviews highlighting that even when there are policies which can be employed to help adapt the road transport sector, the implementation of those policies have not been successful in practice.

> *"In terms of coastal flooding there is polices that you adopt is, which called managed retreat, where you retreat back from the coast and you say I am not building the roads higher and higher and higher to accommodate the coastal flooding, but to say that road is no longer available."*
>
> Respondent from University of Ulster, Belfast

Four participants in Belfast were of the opinion that in the context of climate change adaptation, more attention is needed to be paid for sustainable modes of transport; not only to help reduce the amount of greenhouse gas emissions but also to facilitate the process of climate change adaptation through decreasing the size and number of impermeable road surfaces. Interview data analysis shows that Belfast, as a coastal city, has a high level water table, consequently, there is a little free space between the high water table (associated with the sea level) and the ground level, as a result, the intensity and frequency of flooding due to higher amount of precipitation projected in climate change risk assessments can be increased by increasing the new road construction. Although the dominant view was to give a higher priority to climate change adaptation than its current situation, two participants emphasised on the effectiveness of the integration of mitigation and adaptation measures. The focus of participants in Belfast was mostly on the investment for the public transport infrastructures as an approach to deal with climate change and its impacts. It was highlighted that without an improved public transport system, in terms of both road infrastructure and vehicles, private car usage will be increased in the coming years.

> *"Everybody else is ordering buses but you never hear that Translink have ordered 100 buses from Wrightbus."*

Respondent from Atkins, Belfast

Two participants commented that, in the context of road transport and climate change adaptation, although transport infrastructures have a long operational life, as a result of lack of sustainable thinking, assessments of the transport related proposals have not considered the whole life cycle of transport projects which have consequently decreased the adaptive capacity of existing roadways.

> *"Let me take an example to be the motorway feeding into Belfast. It probably has a design life of 100 years. … They have put a bus lane, but they have removed the hard shoulder to improve the capacity of road by increasing the number of lanes. … The bus lane was not considered at the initial design stage."*

Respondent from Rivers Agency, Belfast

Overall findings of the interviews in Belfast show that although there have been efforts to adapt the road transport systems to climate change impacts, most of the adaptation activities can be categorised in the reactive group of adaptation actions. In other words, even when the existing mechanism has considered the climate change while designing the road projects, it has put more emphasis on the past data during the transport planning rather than emphasizing on the future needs and probabilities. Participants mentioned a variety of barriers in the process of adapting road transport sector to the future impacts of climate change. Those reasons have been discussed in the next sections of this chapter. They will also provide us with a better understanding of the actual progresses that road transport stakeholders have made in terms of climate change adaptation.

4.2.2.2 How Cambridge's Road Transport System is Adapted to Climate Change?

Unlike Belfast case study area, overall findings from the interviews in Cambridge show that climate change adaptation is being considered during the transport planning for new roadways although like Belfast, existing roadways have not received enough attention. Employing Sustainable Drainage Systems (SUDs) for new roads were the most emphasised measures in interviews. However, it was highlighted that Cambridge, being a historic city, has less opportunity to adapt its existing roads to climate change impacts through SUDs.

One third of participants in Cambridge, mostly climate change experts and academics, raised their concerns about the lack of attention paid by transport decision makers to address the long-term impacts of climate change. The majority of critics admit that the climate change adaptation is considered during the road design, but they argue that due to the huge amount of uncertainty about the future impacts of climate change (and also as the result of some political and financial barriers, see Section 4.4 and Section 4.5), transport decision makers have focused mostly on the medium-term projections of climate change impacts. A participant from the Climate Change Centre commented that uncertainty about climate change impacts has a resonance with the existing uncertainties during transport planning which consequently decreases the motivation of transport decision-makers in considering climate change adaptation.

> *"At the moment because of the uncertainty and because of the amount of variability that we already include when we do planning, there simply isn't a lot of impetus for the planners to change much in terms of climate change."*
>
> Respondent from Cambridge Centre for Climate Change

A participant from regional transport authority criticised the existing transport and climate change policy integration, especially, for having a short vision for the climate change adaptation. It was highlighted during the interview that climate change policies are produced as general documents without enough attention to the context of the policy.

> *"If you are doing things like … how do we build the transport network, … I would have thought, you need to look at least to 2050 and probably up towards 2100, if you are going to really get a good sense of what might happening."*
>
> Respondent from Cambridgeshire County Council

Three participants from different organisations emphasised the role of leadership for adapting the road transport systems to climate change impacts. It was argued that because of lack of adequate leadership transport decision makers are not taking the climate change adaptation seriously which consequently leads to reactive and delayed climate change adaptation actions.

> *"I wouldn't say they have done nothing on adaptation, but I think there's been nothing about comparable strengths to give them the impetus to say yes, we must be really working hard on our place. I think to some extent, there's a bit of wait and see attitude that says that we probably have a good more time to respond as we see these things happening."*
>
> IPCC lead author from University of Cambridge

There were a few comments regarding the provision for sustainable modes of transport. Findings show that majority of participants are satisfied with the progress of sustainable modes of transport in Cambridge, e.g. public transport, walking and cycling, but high growth of population and high price of housing due to the density of the city and lack of enough land for new developments were perceived to be the major concerns for increasing the average distance of home to work travel in the area. This in turn leads to a modal shift from sustainable modes of transport to private car use. They argued that provision of the public transport for people who are living outside the city has been problematic within the amount of available financial resources even with subsidising the public transport by Cambridge City Council. As discussed in the following sections of this chapter, there are a variety of barriers, most specifically funding issues, that have impeded the effective delivery of sustainable transport objectives.

> *"The county [council] has a strong and long-standing investment in Cycling and has a cycling team, it just concentrates on cycling and cycling infrastructure and it has a list of all these areas that need improving."*
>
> Respondent from Travel for Cambridgeshire Partnership

> *"Cycle provision for cyclist is improving, it could be better but it is improving."*
>
> Climate change expert from Cambridge City Council

4.2.3 Integration of Climate Change Adaptation with Other Policy Domains

Regarding the priority of mitigation and adaptation, majority of participants in both Belfast and Cambridge argued that climate change mitigation has received more attention than the adaptation, though adapting to climate change can have more benefits to the local area than reducing the amount of greenhouse gases. The dominant view was that measures for climate change mitigation can benefit the local level through decreasing air pollutions and health problems but as a result of the global impacts of climate change, reducing the amount of greenhouse gases will reduce climate change impact at the global level and will not significantly reduce the impacts of climate change at the local level. Thus adapting transport sector to the local climatic condition should have a better priority for the government than focusing on greenhouse gas emission reductions. Findings show that lack of public awareness and demand for climate change adaptation has resonance with the lack of political will at the local level. However, a participant from Cambridge related the high attention of local politicians to climate change mitigation to the political issues at the national and international levels which motivate the local politicians to pay more attention to the reduction of greenhouse gas emissions. However he was of the opinion that due to the complexities involved in the process, it usually takes more time than it does for the adaptation; as a result it is necessary for national governments to put more emphasis on the climate change mitigation.

> *"To some extent I have sympathy with that, the mitigation efforts take decades to bringing a change, it takes decades to happen, it takes more decades to that all work through the climate system, really have to be planning many decades ahead to try and work out what's gonna happen with mitigation."*
>
> IPCC lead author from University of Cambridge

Another important theme discussed in the interviews was about the interconnection between different sectors regarding climate change and the priority of those sectors in climate change adaptation. Majority of participants related climate change adaptation in transport sector to at least one or more other sectors (mostly housing sector). The findings from the literature review confirm that decisions about climate change adaptation in transport sector cannot be made without considering the other sectors' policies. There were two attitudes about the priority for transport sector in adapting to climate change Impacts. The first and dominant attitude was that due to the financial constraints some other sectors such as health, education and housing need more attention than transport sector. On the other hand, the opposing attitude was that due to the appropriate consistency between the long-term operational period of transport infrastructures and long-term impacts of climate change, the implementation of climate change adaptation policies in transport sector is an efficient approach and should receive a higher priority. However, there was a critic for this second viewpoint. A participant commented that roadways are usually being repaired or resurfaced every 15-20 years as a result road transport sector will have more opportunity than other sectors to adapt itself to the future impacts of the climate change.

> *"If you are doing things like how do we layout our city how do we build the road network, how do we build the transparent network, a lot of that is decades and decades of time to get right on them."*
>
> Respondent from University of Cambridge

> *"Every 15- 20 years we completely change our road transport system or we resurface or we rebuilt roadways. So I don't think anybody has the incentive to look far enough out at the moment."*
>
> Respondent from Cambridge Centre for Climate Change

The following sections present the main barriers for an effective and efficient implementation of climate change adaptation policies within the road transport sector at city level. Data analysis shows that almost all factors have a significant correlation with at least one other factor. However, this section categorises them in five main themes and within each category the impact of each factor/barrier on other factors will be discussed in further detail. Then Section 4.8 will discuss those correlations to find out the main factors influencing the process of climate change adaptation, and generate the final Q set for the next phase of the research.

4.3 How Important is the Role of Climate Change Uncertainty?

In both case studies, uncertainty about the future impacts of climate change was perceived to be a significant barrier during the process of climate change policy implementation. However, the focus of the participants in Belfast was on uncertainty in the acceptance of climate change, especially at the national/regional level, while the participants in Cambridge mostly emphasised the role of uncertainty in funding allocation process. As discussed in Section 4.2.2, although both cities have not had a perfect progress regarding the integration of climate change adaptation policies in transport departmental decisions, Cambridge has made much better progress in terms of at least considering the future impacts of climate change even though participants criticise the lack of attention paid by transport decision makers to long-term impacts of the climate change on transport systems. As discussed in the following sections, political barriers and budgeting issues are the most important set of barriers in Belfast and Cambridge, respectively. However, it should be emphasised that uncertainty about the climate change can be recognised as the origin of those factors which creates a non-rational environment/opportunity for some actors involved in the process. This section presents some of the statements made by the study participants regarding the uncertainty about climate change impacts. Then the relationship between this important factor and other economic, political and institutional factors will be discussed in further detail later in this chapter.

A common theme in the interviews was that there is not enough information regarding the prediction of future impacts of climate change at the local level. In other words, not only is not there a clear information about the possible effects of climate change on road transport sector, but there is not also a practical picture to help transport decision makers have a better understanding about the direct impacts of climate change. A participant from University of Cambridge related this issue to the lack of knowledge at the national and global level about the climate change and its possible impacts. Findings from literature review confirms this argument. As discussed in Chapter 2, even at the global level, predictions for climate change impacts during the last decades were not accurate and indeed every IPCC report emphasised on more changes in the climatic situation than its previous reports did. So, it is not very interesting that why the national transport authorities have not been able to produce such a detailed climate change risk assessments for local levels.

> *"Although we have some sense of what might happen globally, we have some feeling for how the temperatures are likely to rise over the next 50 or 100 years, getting that translated down into what might actually happen as an individual location is very very difficult to do."*
>
> IPCC lead author from University of Cambridge

The opposite viewpoint in Cambridge was that the national transport authorities cannot and should not provide the local transport decision makers with detailed guidelines about the climate change. It was argued that the current approach gives more flexibility the local transport authorities in considering the needs of their jurisdictions. Participation of local stakeholders in assessing the risk of climate change at the local level was an emphasised suggestion to deal with uncertainties around the climate change. Research communities, non-transport local organisations and transport users were the most frequently mentioned stakeholders in interviews.

> *"I would have hoped by certain research could be done into getting sort of better surfaces, those haven't already been done though we're already suffering those kinds of temperatures."*
>
> Respondent from Cambridge City Council

> *"UK is already experiencing problems with flooding and there's no evidence to say that is because of climate change, just because of urbanisation, because of green spaces have been taken out because woodlands have let being neglected, so how related these are in terms of climate change impact, it's unknown quantity".*
>
> Climate change adaptation expert from University of Cambridge

4.4 Policy Initiation and Socio-Political Barriers

The analysis of interviews shows that socio-political barriers are the most significant set of barriers in Belfast. These factors are recognised to be the second most significant group of barriers in Cambridge after funding and budgeting issues. There is a considerable correlation between this theme and social barriers in climate change adaptation (i.e. acceptance of climate change) and existence of the uncertainty around the future impacts of climate change in both case study cities, though the correlation between the political and financial barriers is much stronger in Cambridge. To clarify all these relationship, the political factors and the role that the social barriers have played in the creation of such a political atmosphere are discussed separately for each case study area. This section is focusing on the relationship between the demand for climate change policy, public awareness of climate change impacts, uncertainty and other political factors at the initiation phase of climate change adaptation policy cycle. Moreover, this section highlights the interconnection between these political factors and effective working relationships between different stakeholders involved in the policy implementation process.

4.4.1 What Are the Main Socio-Political Barriers in Belfast?

The conflict between different political parties at the national/departmental level was perceived as a major barrier for sustainable transport and climate change adaptation objectives. In Belfast case study, it was underlined that the political conflict between Department of the Environment (DOE) and Department for Regional Development (DRD) has impeded the degree of coordination on shared matters including the climate change adaptation.

> *"One party would say we don't support this because you are not supporting us on this aspect. The other party would say we are not supporting your Regional Developing Strategy, your minister doesn't belong to us and you didn't support us on the Climate Change Act."*
>
> Respondent from Rivers Agency, Belfast

> *"The regional development (DRD) have control over Translink and road authority. So you have got the SDLP sitting in Department of Environment … and DRD, officially unionist. But the two heavy weight boxers are not involved anywhere in those departments."*

Respondent from Charles Tennant & Co, Belfast

As discussed in the literature review, due to the uncertainty about climate change impacts and its resonance with the long-term nature of transport infrastructure, climate change adaptation in transport sector is a complex process. Participants raised their concerns on this issue by emphasising that as a result of political conflicts among different political parties there is a lack of joined-up thinking at the departmental level, specially between DRD and DOE, which is hampering the process of climate change adaptation.

> *"I want to think positive, but I'm doing from 2006. They are fighting … looking for short time wins. …."*

Respondent from Northern Ireland Environment Link, Belfast

Three participants from Belfast were of the opinion that the conflict between different political parties regarding the climate change issue is not limited only to Department for Regional Development (DRD) and Department of the Environment (DOE), but it can be also seen between other departments. They mentioned this political barrier as the major barrier in the way of the Climate Change Bill.

> *"A Common Agriculture Policy (CAP) going on at the moment in the rest of the UK have allocated whatever percentage of CAP money to greening and other environment schemes, and DARD minister, wanted to allocate 7% to greening and that was challenged in the court by the DUP, and we ended up with zero."*

Respondent from Friends of the Earth, Belfast

> *"The climate change bill is supported by head of the Department of Environment minister, but it may not be supported by other ministers in the way it's written and hasn't gone to it, may not go to it."*
>
> Respondent from Rivers Agency, Belfast

Belfast participants reported a variety of factors which reduce political will and supports consequently they impact the delivery of climate change-related policies and sustainable transport measures. Three main themes can be extracted from these discussions. Firstly, it was argued that since there is a doubt about climate change among politicians, there is not enough political support and will for climate change adaptation. Uncertainty about climate change and its impacts was perceived to be a key barrier against creating enough political will.

> *"I'm meeting the Environment minister and other groups as well next week. I think the purpose of it for him is to say listen we are not gonna get a climate change. So what we gonna do to progress the climate change? … I'll see what he says."*
>
> Respondent from Northern Ireland Environment Link, Belfast

> *"Very recent Environment minister doesn't believe in global warming."*
>
> Respondent from Freight Transport Association, Belfast

> *"90% of science suggest that climate change is happening, most of the scientists. But there is difficulty there. … There is certain people in government that are skeptical about climate change."*
>
> Respondent from Atkins, Belfast

> *"When a Climate [Change] Bill comes along, there is certain elements within the legislative council there that says: right, we don't believe that greenhouses are man-made. We do not believe in the science that you are suggesting. Yes, we see significant defends, but they are not to defend change variations, we are waiting for greater evidence. … So, it is not easy."*

Respondent from Rivers Agency, Belfast

Secondly, it was argued that the tension between short-term electoral cycle and long-term nature of climate change has reduced the political will. Participants were of the opinion that not only does the short electoral cycle not motivate them to work against the climate change, but the cabinet reshuffling does not also allow them to drive forward the climate change policies.

> *"Decision making processes are built around a four or a five year period of election to a parliament and those are attempting to deliver something in that period of time. So to get them to buy into the idea, we gonna to climate change mitigation and adaptation, is very difficult, because they don't see the return on their efforts".*
>
> Respondent from Atkins, Belfast

> *"Politicians are in the job, in mainstream politics for four or five years. Here, our politicians could be in a job for 18 months and then they get reshuffled. 18 months is not a long enough period to formulate and drive forward a politician's own thinking or even a party's own thinking".*
>
> Respondent from Charles Tennant & Co, Belfast

Thirdly, participants raised their concerns regarding the lack of attention paid by politicians to climate change adaptation measures and sustainable modes of transport such as public transport and cycling. It was argued that the existing funding process which looks at short-term returns cannot be an effective mechanism for the delivery of climate change adaptation measures and sustainable transport objectives. Participants shared their concerns that politicians have a critical role in prioritisation and funding of transport projects. The supporters of this theme argue that there is not enough demand from the public in order to convince politicians to give a higher priority to climate change adaptation. It was argued that since the probability of climate change impacts (such as flooding) is very low, there is not enough public demand as a driver for the political will and support. A participant from Northern Ireland Cycling Initiative raised his concern that moving towards the sustainable modes of transport such as cycling is not a high priority for both national and local politicians. Again it can be concluded that more awareness raising about climate change and sustainable transport is needed among the public to create an atmosphere for changing politicians' attitudes at the local and national levels towards the sustainable transport.

> *"They [Transport NI] are getting money because politicians, they want to be in the local newspaper to say that I did for this time etc., so vote for me. But if it comes to the gully sucking or pothole repairs, that money has been withdrawn from them."*
>
> *(Respondent from Freight Transport Association)*

> *"Many MLAs and councilors just don't get cycling as a cheap, efficient, inclusive, healthy, noise and emission free transport mode of transport. Politicians are servants of motorists."*
>
> *Respondent from Northern Ireland Cycling Initiative, Belfast*

However, a participant from the Rivers Agency made an opposing proposition. It was argued that most of the decisions made by politicians aim to improve Northern Irish people life style. It was explained that the devolved administration within Northern Ireland is relatively new and must be appreciated. It was argued that because of the nature of the devolved administration and shared devolution in Northern Ireland, "*a little bit of maturity*" is required in terms of delivery of local administration and "*that will come with time*".

4.4.2 What Are the Main Socio-Political Barriers in Cambridge?

Although participants from Cambridge mentioned a few statements regarding the negative role of uncertainty in creation of a political atmosphere at the national level in the implementation of climate change adaptation policies, findings show that political factors are much stronger at the local level. The main theme in the interviews was that the Cambridgeshire County Council as transport authority does not pay enough attention to climate change. A local politician from Cambridge related this issue to differences in the awareness of voters about climate change and sustainability at different scales.

> *"There're people who don't care at all. They just want to be able to drive wherever they like whenever they like, and there are people who are absolutely disgusted to the councils on talking climate change seriously."*
>
> Respondent from Cambridge Cycling Campaign

> *"I think one of the problems of Cambridge is that the county council is run by interests from the north of the county that they don't know Cambridge, that is not just climate change issue, it's more to do with. … The more population of Cambridge is more aware of this fact, therefore would be willing to pursue policies that are more favorable to address the climate change than the majority of county council. They just don't believe it, they are not taking it seriously."*
>
> Local politician from Cambridge

A common theme during the interviews was that there is not sufficient demand from the public to push politicians to pay more attention to the climate change adaptation at the national level. The need for awareness raising activities for climate change adaptation was highlighted in the interviews.

> *"If you are a politician you cannot try to oil the squeaky wheel. … They are not complaining about adaptation. So I won't do anything about it yet."*
>
> Respondent from Cambridge Centre for Climate Change

"It is a matter of getting agreement and taking people with this, the big problem with democracy is the voters. You need to convince them that what you need to do and that is very slow and difficult process."

Respondent from Cambridgeshire County Council

Three participants argued that the level of public awareness about climate change and sustainability has had a strong impact on the process of sustainable development in the recent years. Although it was argued that people in Cambridge have a good understanding about the sustainability and climate change mitigation, a participant from academia commented that, because of the nature of adaptation activities, public's views about the climate change adaptation are difficult to become a supportive one when comparing with the climate change mitigation.

"I don't find any citizens, individual citizens, thinking about adaptation. … Everybody understands mitigation, because there's something they can do to help with mitigation. Adaptation, an individual can't really do anything with the adaptation in order to adapt the roadways or something, that's a billion pounds."

Respondent from Cambridge Centre for Climate Change

A participant from academia criticised this viewpoint. It was argued that the climate change should not be limited to direct impacts. Raising the public awareness about indirect impacts of climate change was suggested to be an effective approach for increasing the public demand for climate change adaptation activities by politicians.

"There are other indirect effects that occur because of climate change. … Other economic and social consequences are probably the most important things that people neglect about climate change. "

Climate change adaptation expert from University of Cambridge

In addition to the public awareness about climate change and its effect at the national/local politics, it was argued that regardless of the geographical scale, the public awareness about climate change adaptation is not enough even among some professionals who need to consider climate change adaptation in their decision makings and plans.

> *"Understanding of adaptation is still quite low. I have been in meetings where I've heard architectures say what is sustainable drainage? … I don't think they don't necessarily view things like green infrastructure or blue infrastructure. I don't think they view those from the climate change perspective, so I think it's just changing the way in which people view things. There is a lot of work going on. There is a lot of organisations who are promoting adaptation, but I think still more work is needed to get that message."*
>
> Climate change expert from Cambridge City Council

> *"This is certainly true that the highway authority seems to just haven't got the message about sustainability and change the approaches at all. So they are just as they worked 40 years ago when I came in."*
>
> Local politician from Cambridge

There was a contradictory opinion regarding the awareness of local decision makers about sustainable transport. It was argued that sustainability is considered in the decision making process on transport at the local level, however, the main conflict is around the best way to deliver the sustainable transport objectives. Similarly, a climate change expert from Cambridge City Council was of the opinion that although local politicians' understanding about climate change adaptation is different from the scientists' understanding, recent impacts of climate change have played a positive role in increasing their attention to the climate change adaptation.

> *"Most of the city politicians and quite a number of county council people are much more in favour of the sustainable transport. So the arguments are between the best way to do a cycle lane, not whether there should be a cycle lane."*

Ex-councilor of Cambridge City Council

"I think local politicians are aware that this is an issue that our transport network does need to be more resilient because these episodes are becoming more frequent."

Climate change expert from Cambridge City Council

4.5 Funding Mechanism and Financial Issues

Availability of funding for transport sector in general and the existing funding mechanism in particular were perceived as key barriers for the delivery of sustainable transport policies in both case study areas. However there are considerable difference between attitudes of participants in Belfast and Cambridge regarding the prioritisation of projects. Majority of participants from Belfast were more concerned about the construction of new road infrastructure which leaves less opportunity for provisioning of the public transport and cycling infrastructure. The second important theme raised by Belfast participants was the political influences in decision making process of transport matters. It was argued that as a result of the uncertainty of climate change impacts and a lack of political support, there is a little attention towards climate change adaptation and sustainable transport objectives which consequently increases the political influences in decision making process and spending the available funding.

Participants in Cambridge have different attitudes regarding the funding mechanism of transport projects. Inconsistency between local transport plan and national funding mechanism was highlighted as a major barrier for delivery of sustainable transport policy objectives. It was followed by the lack of a long-term and coherent transport plan which considers the actual available resources. The following section discusses these funding barriers for two case study areas. In order to contrast the similarities and differences between those factors in Belfast and Cambridge, Section 4.5.1 and Section 4.5.2 highlights the most important financial barriers perceived by study participants in Belfast and Cambridge, respectively.

4.5.1 How Effective is the Funding Mechanism in Belfast?

Insufficient allocation of funding for transport projects was highlighted in all interviews. A common theme was that the Department for Regional Development (DRD) has limited the power over decision making and prioritisation of transport projects. A participant from the Rivers Agency criticised the role of politicians in the allocation of the financial resources to different projects. He argued that as a result of insufficient available financial resources, politicians tend to give higher priority to projects that needs less resources which consequently persuades the departmental decision makers to underestimate the initial costs of the projects.

> *"There is a little bit of politics involved there. … If I say this project can cost 20 million, it will never get off the ground. If I say this project cost 10 million I may get yes and as you go on and you find that 10 million."*
>
> Respondent from Rivers Agency, Belfast

Majority of participants argued that although there have been efforts to implement sustainable transport measures and policies, the delivery of those activities were not effective in practice. A lack of public behavior change, a lack of joint-up thinking regarding transport and land use planning issues and a lack of financial resources for the public transport and road maintenance due to the emphasis of transport decision-makers on construction of new roads were perceived as the main barriers for the implementation of sustainable transport strategies.

> *"That's a 10-15 year period where a very little concentration of public transport improvement. … It should have been upgraded, it is second third world country almost."*
>
> Respondent from Atkins, Belfast

Another important theme was related to the prioritisation of transport projects. Participants raised their concerns about the focus of the government on the construction of new roads which provides less budget and opportunity for the maintenance of the existing infrastructures and effective delivery of sustainable transport measures. In addition, a lack of attention to the maintenance of non-motorised transport infrastructure was highlighted by two participants.

> *"The problem is they [Transport NI] are getting lots of funding, but to construct new roads. But they have had 17 million withdrawn from their budget for roads maintenance on the B class roads and some of the A class roads."*
>
> *Respondent from Freight Transport Association, Belfast*

> *"Surprising as West Belfast 50% households have no access to a car, but got a 3rd lane on the Westlink."*
>
> *Respondent from Northern Ireland Cycling Initiative, Belfast*

Two participant from transport planning consultancies emphasised that sustainable transport has not received enough attention in the transport planning process within Transport NI (road service). According to them, the transport planning process is mostly focused on cars which impedes the delivery of sustainable transport objectives.

> *"Problem is when you are a consultant worker in the road service, you have got your hands tight behind your back. Because you can't actually say what you want to do, because everything is focused for the car. They don't care about looking at pedestrian issue or cycling issues, 95% is car."*
>
> *Respondent from SW Consultancy, Belfast*

Another theme in the discussions regarding funding issues was related to the negative impact of uncertainty around the climate change on effective financing processes. It was emphasized that clear climate change risk assessments and clear guidelines for integrating climate change into departmental decisions are two necessary elements of effective financing processes.

> *"One of those question not sure how exactly to measure it? … How does that actually translate itself into climatic change? It is difficult to understand therefore, it is difficult to allocate funding?"*
>
> Respondent from University of Ulster, Belfast

A participant from academia criticised the existing approach for monitoring the integration of climate change adaptation into transport projects. He suggested that the evaluation of climate change adaptation should be combined within the sustainability thinking of the whole process of transport projects rather than just allocating a certain amount of resource for adaptation.

> *"You could take a project and say x percentage of the contract price goes towards the construction of the SUD [Sustainable Drainage System] elements of the road. It's becoming more common. My gut reaction probably talking about maximum 3 to 4 percent towards SUDs. … Ideally it should be the whole road construction process and the kind of materials used and how that performed as we get warmer climate change."*
>
> *Respondent from University of Ulster, Belfast*

4.5.2 How Effective is the Funding Mechanism in Cambridge?

Participants from Cambridge shared similar concerns regarding the allocation of financial resources to transport projects for addressing the climate change. However, there was a considerable difference between their attitudes and Belfast participants' attitudes. Findings revealed that in Cambridge the funding constrains are the main factor which limit the implementation of climate change adaptation policies, while in Belfast political issues were stronger.

> *"The councils can't even afford to fix that potholes on the roads. They certainly can't afford therefore to be doing anything for adaptation."*
>
> Respondent from Cambridge Cycling Campaign

It was frequently discussed that due to the funding available for local authorities, they do not have enough staff to consider on climate change issues while planning and decision making of transport projects. Findings showed that the second main barrier against the implementation of sustainable transport policies is largely related to the change in the demographic structure in the area which again imposes enormous funding pressure for local authorities to deliver sustainable transport objectives.

> *"Even though the councilors are eager to do something here, they can't hire somebody they don't have the money to hire somebody."*
>
> Respondent from Cambridge Centre for Climate Change

> *"National government just shift all these responsibilities on to the council but the council don't have the resources to do any of these actions."*
>
> Respondent from Cambridgeshire County Council

A lack of joint-up thinking between transport and planning authorities at the local level, and a lack of a comprehensive funding plan from the national level were also perceived to be major economic barriers for the implementation of climate change adaptation policies in Cambridge. It was argued that these factors increase the political influence during the decision making process of transport matters at the local level and finally lead to at least a delay in the delivery of sustainable transport projects such as cycling infrastructures. Moreover, a lack of research about the costs and benefits of climate change adaptation was perceived to be a major issue which prevents private sector to get actively involved in the process of climate change adaptation.

> *"The transport planning is essentially aspirational. It's planning to spend lots of money, but the money doesn't exist. So a lot of what is in the transport plan won't happen soon."*
>
> Respondent from Cambridge City Council

More than two third of participants argue that local authorities are under a high financial pressure. Discussions revealed that the officials and responsible people concerned with climate change adaptation issue from the national to the local level has not paid enough attention to funding matters. The limited number of climate change experts, as a result of financial limitations, was considered as a major issue for integrating climate change adaptation policies into transport and land use planning policies. Findings showed that climate change positions are the first options at the local level to get abolished when there are budgetary issues.

> *"There used to be a climate change section in the county council but that was disbanded a couple of years ago as a result of the cuts in the local authority."*
>
> Respondent from Travel for Cambridgeshire Partnership

One of the main themes discussed in the interviews was related to the lack of long term funding strategy for transport projects. Participants listed a variety of resources for local transport plans and projects ranging from national funding resources to the contribution from local development plans (Section 106) as well as Greater Cambridge City Deal[43]. This deal was agreed by the government and aims to create an infrastructure investment (including transport) and accelerate the delivery of more than 33,000 planned homes through improving the joint-up thinking between the local councils. However, it was argued that a lack of comprehensive financial plan for transport projects is a major issue for the effective delivery of sustainable transport objectives. They criticised the government approach in determining the use of allocated money to the local authorities.

[43] See this link for more detail on Greater Cambridge City Deal: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/321722/Greater_Cambridge_City_Deal_Document.pdf

"There is considerable amount of program funding, funding for particular projects, funding for particular themes, rather than a comprehensive, look up at the strategy, what we wanted to do and funding that appropriately."

Respondent from Travel for Cambridgeshire Partnership

Two participant also criticised the instability of the funding mechanism of the local authorities. The complexity involved in the funding formula for the local authorities was recognised by them as an obstacle in finding a rational approach for developing local transport plans.

"The funding formula for local authorities is usually changed where you should change a government because the formula is very complicated and you can weight this and you can weight that."

Respondent from Cambridge City Council

"Because of the funding issues it's very difficult to set down a rational route forward. You set down the parameters by which, but then there's a subsidiary for this or this for that or this money gets withdrawn and it effects how you can get a rational maximum benefit for your policy".

Respondent from Cambridgeshire County council

Another important theme of discussed was related to the short-term funding deadlines. It was argued that planning transport projects involves a large amount of uncertainty in terms of the timeline of projects; it is very difficult to predict the exact timeline of large infrastructure projects. Therefore, the existence of "tight" deadlines on financial resources will force the transport decision makers not to consider different issues including climate change adaptation in detail.

"Central governments need to provide more coherent funding, rules, money or whatever in longer time-scale. What needed is to know what sort of projects governments can to be funding in 15 years time, so you can proper planning. … Long-term financial stability is missing."

Ex-councilor from Cambridge City Council

"One of the problems now is so much this governments money is provided on the basis must be spent by a deadline which is often quite tightest too, to consider things in enough detail because the scheme has to be delivered by March next year or whenever. … So there isn't time to redesign it to really satisfy concerns. … For big projects it's difficult to judge accurately how long it takes to deliver."

Local politician from Cambridge

Three participants, all climate change experts from academia and Cambridge City Council, raised their concerns regarding a lack of knowledge about the cost and benefits of adaptation. It was argued that as a result of uncertainty about the future impacts of climate change, decision making and planning for climate change adaptation require more research to find efficient adaptation measures at the local level. The lack of financial resources for local governments to fund those researches was also highlighted by them.

"What probably hasn't been done so much is to way up the costs and benefits in the same way as we've done for mitigation. … I think it has been much more difficult task trying to work out should we doing a lot more adaptation than we are doing at the moment or should we going quite cautiously doing those kinds of calculations. Taking account of the whole uncertainty is very difficult to do."

IPCC lead author from University of Cambridge

"I think the key issue is the resources to actually implement adaptation and resilience measures. I think a lot more work need to be done to process the business case for resilience measures, because I think all local authorities are in enormous pressure financially and budgets are being cut and it's what you can do within those budgets."

Climate change expert from Cambridge City Council

> *"All councils are in enormous pressure now financially, … so couldn't really expect the councils here to fund that themselves, you need to get research funding grant, something from central government or research councils or whatever to trying to put these things in place. I recognise it is very difficult position in terms of funding at the moment."*
>
> Climate change adaptation expert from University of Cambridge

The conflict between City Council and County Council regarding land use planning matter was perceived to be a major issue in the delivery of sustainable transport objectives. It was argued that since the County Council is representing the interest of those people who are living outside the city and working inside the city, due to the creation of public transport service monopoly model, County Council has not paid enough attention to providing appropriate bus service. County Council, therefore, has not made effective progress in the mitigation of the impacts of new development plans even though developers have paid a considerable amount for this purpose. A participant raised his concern about the accountability of the city council to the local public regarding the provision of bus services.

> *"One of the criticism that I have is a lot of money is being collected to pay for transport mitigation of the developments which the county council is having difficulty. Because they are the highways authority, so that money goes to them and the results doesn't seem to be very effective".*
>
> Local politician from Cambridge

> *"People think the city council has more influence than it does. …The city council subsidises more bus services in the county now, even though subsidising bus services is a county council duty."*
>
> Respondent from Cambridge City Council

The contradictory attitude was that due to high housing price in Cambridge and the high rate of population growth in this area, there is a considerable increase in the number of people who are living outside Cambridge city and are working inside the city. They argued that due to funding constraints the county council is facing, it is very difficult for them to subsidise bus services.

> *"We have a major issue with a massive rate of growth in the city, population growth is quite extraordinary. So we cannot accommodate everyone within the city boundaries that is a major issue because it means that about two thirds of the new people who be employed here have to travel probably by car."*
>
> Respondent from Cambridge City Council

> *"Because of the property prices, we have a lot of long distances travelers into the city because a poorer people cannot find a house to buy anywhere near here. … The rate is ridiculously high for renting."*
>
> Respondent from Cambridgeshire County Council

> *"It's a matter of the slow rate which you get the money to do things and the slow rate at which you get agreement from the different organisations that need to be signed up."*
>
> Respondent from Cambridgeshire County Council

There were three opposite attitudes regarding the traffic in the city. The first attitude saw the existing traffic as an evidence of the ineffective progress of transport planning. The second viewpoint saw the existing traffic as an opportunity for moving towards sustainable modes of transport. And the third attitude was that there is not a good vertical coordination between highway authorities at the local and national levels.

> *"Transport challenges generally are that the traffic moves very slowly on the roads and therefore we are increasingly turning to bicycles … My wife and I don't drive a car, not because we don't like cars but because if you get in a car it going to take you 5 times as long to get some place in the city as riding out of bicycle".*
>
> Respondent from Cambridge Centre for Climate Change

> *"One of the major advantages of Cambridge is its compact nature which is why we should have cycled here."*
>
> Respondent from Cambridge City Council

> *"Cambridge is so compact, it is much much quicker to cycle across the city than it is to drive, you can I would say from the city centre, you know 15 minutes bike ride from the edge of the city, much much quicker."*
>
> Climate change expert from Cambridge City Council

> *"I still find it extraordinary that the A14 improvement scheme which in geographical term is still quite a small scheme, is fabulously expensive, one and half billion pound pays for nothing, …, certainly give us a fast railway all the way from Cambridge to Oxford. …There's a lot of concerns in the city that, it will generate additional traffic towards the city".*
>
> Respondent from Cambridge City Council

However, a participant from Travel for Cambridgeshire partnership[44] highlighted the negative role of high density of the city in the absence of cycling facilities in new developments.

> *"House prices in Cambridge and around Cambridge are very very expensive. So developers want to make them as dense as possible. … It's affecting the viability of a development. If a developer sees that the council is asking for too much, it will say things like we can't afford to do that because it means we will not make our profit."*
>
> Respondent from Travel for Cambridgeshire Partnership

[44] Previously known as Travel for Work (TfW)

4.6 Decision Making Process & Policy Barriers

This section presents the findings about the decision making process of climate change policy and strategies within the road transport sector. Findings show that Belfast participants are more concerned about the lack of political will at the national/regional level which consequently impedes the translation of climate change policies to the local level. They criticised the lack of guidance for integrating climate change adaptation policies with transport decisions. The second most important issue is related to the lack of integration between sustainable transport policies and land use policies. Similarly, Cambridge participants shared their concerns about the unclear vision of the national government regarding climate change adaptation. However, the main focus of Cambridge participants was on the integration between transport and land use policies, and the lack of funding to monitor this integration process.

4.6.1 Policy Barriers for Climate Change Adaptation in Belfast

As discussed earlier in this chapter, participants emphasised the uncertainty about the impacts of climate change and a lack of political will as the main barriers to the Climate Change Bill in Northern Ireland. These barriers have had negative impacts on the translation of climate change objectives into the design standards and guidance. The availability of guidelines and standards for the use of local level decision makers was highlighted during the interviews.

> *"I would suggest that the availability of guidelines, specifications and standards. They are part of the intellectual component that have to make that decisions regarding transportation and climate changes, so they need to be readily available."*
>
> Respondent from River Agency, Belfast

Participants criticised the existing road design standards which was created based on the statistical analysis of the past data. Suggesting for employing a proactive approach which considers scientific evidences about climate change in the future and its impacts, it was argued that the existing reactive road design standards cannot lead to the long-term resiliency of road transport system.

> *"Design standard for the drainage from the road gives a one-off five years return period. That is based on the statistical analysis. … Climate change is not over 1 to 10 or 20 years, it is over a period of hundreds of years. The climate change is increasing over those 200 years. … So, our design standards are not able to drain away that water and if we do not manage that water then that water cause the transportation network."*
>
> Respondent from Atkins, Belfast

Highlighting the provision of guidance and the design of standards, it was also emphasised that regardless of climate change and its uncertain impacts, transport planning itself requires to deal with the surrounded contingency which impede the effective decision making.

> *"At the initial stage of the project we don't have the information or most of the contingencies are in place that you should be adding a large contingency on because there is a lot of unknowns at the start of a the project and as you go through the project the unknown are reduced."*
>
> Respondent from SW Consultancy, Belfast

Lack of 'joined-up thinking' about climate change adaptation and transport policy and strategy development was frequently criticised during the discussions.

> *"Regional Transport Strategy (RTS) was developed for transportation. It wasn't developed for adaptation to climate change. … What I will say when they were developing the regional transportation strategy, they did not give a lot of consideration to climate change adaptation."*
>
> Respondent from Institution of Civil Engineers, Belfast

The existing "predict and provide" approach was perceived to be an ineffective way of responding to climate change impacts in transport sector. A participant from Northern Ireland Environment Link suggested that the integration of climate change adaptation policies into transport policies should follow the rules of sustainable development through integrating different elements of transport planning with each other.

> *"Everything regarding climate change adaptation has to be sustainable. So, that really is not sustainable to put bigger and bigger pipes or bigger and bigger gullies to deal with the water. There is a way to manage that water and the best place to manage that water is on the surface rather than putting it underground out of sight out of mind, because it is likely just to pop-up somebody's house. At the minute we spent enough a lot of time doing landscaping of streets, renovation of streets where we put in, flower pots, trees etc., but we have no consideration of how that water on the road can be used to feed these plants, feed these areas."*
>
> Respondent from Northern Ireland Environment Link, Belfast

An effective integration between transport and land use policy was strongly recommended by the participants. It was argued that the existing planning and transport policy frameworks are not consistent and consequently cannot help the effective delivery of the sustainable modes of transport.

> *"We seems to have had some policies that encouraged dispersed settlement and then we have some difficulty that we don't have public transport infrastructure to deal with that disperse settlement".*
>
> Respondent from Atkins, Belfast

A lack of strategic thinking about road transport system was perceived to be a major barrier for the implementation and delivery of sustainable transport policies not only in terms of implementation of climate change adaptation policies but also regarding the delivery of sustainable modes of transport such as walking and cycling. As highlighted in Section 4.54.5, majority of participants criticised the focus of the government at the national and regional level on the construction of new roads. They argue that not only can the construction of new highways cause the budgetary issues in the facilitation of the delivery of sustainable modes of transport, but it can also motivate people to move away from environmental-friendly travel modes to private car use.

> *"There's no one seems to be thinking about how can we reach out population centers. You are improving the A1, great motorway. But you are not going to get people out of the cars, you are encouraging. People don't like to be switched from I would say free flow of traffic. I think the main barrier is the lack of strategic thinking about transport in Northern Ireland."*
>
> Respondent from Freight Transport Association, Belfast

4.6.2 Policy Barriers for Climate Change Adaptation in Cambridge

Three main themes regarding the decision making process of climate change adaptation in transport sector were discussed by Cambridge participants. The first theme was related to the lack of national policies and clear vision about climate change adaptation. It was argued that the national government has passed all responsibilities regarding climate change adaptation to local level actors without supporting them with the required funding and guidance. A lack of knowledge about the available measures to adapt road transport to the future impacts of climate change was considered to be a major barrier. It was argued that the national policies put less attention upon climate change adaptation than that they do upon climate change mitigation and reduction of greenhouse gases.

> *"What is needed at the national level is a clear view on climate change adaptation, I know we've got national adaptation plan, … I think that could*

> *have more within it. … It would be easier if national legislation came forward and was actually adapted when it was supposed to be."*
>
> Climate change expert from Cambridge city council

> *"Policies just say they you are taking to account climate change adaptation measures, then you're thinking about what those measures are?"*
>
> Respondent from Cambridgeshire County Council

> *"If you want to reduce the amount of greenhouse gases we're emitting then yes there is certain things we're doing with pushed by central government to try and do something in that area. In terms of the adaptations so difficult to see what to do."*
>
> IPCC lead author from University of Cambridge

The second theme was about the gap in adaptation policies at the local level. The supporters of this viewpoint were mostly from academia/climate change experts. They critisised the local adaptation policies developed by local authorities for not having a clear vision or action plan. The lack of expertise as a result of financial constraints was perceived as the main barrier for developing the local adaptation policies. However, it was argued that in the existing adaptation policies climate change mitigation has received most of the local policy makers' attention.

> *"They have a document that call their adaptation policy and it is completely vague and promises things but no engineer has ever looked with that, no finance officer have looked on that so they don't have the personal expertise and they don't have the money to do this sort of stuff."*
>
> Respondent from University of Cambridge

> *"Cambridge really doesn't have a formal adaptation plan at the moment. It's just hired a new climate change officer and this officer is supposed to look at adaptation in the transport sector. … The only thing that we've looked at here*

> *in Cambridge for climate change is climate change mitigation, the emissions from it."*
>
> Respondent from Cambridge Centre for Climate Change

However, one of the participants from academia was of the opinion that the existing policy documents at the local level in Cambridge should been taken as a positive point in making progress regarding climate change adaptation issue since most of the councils in the UK even have not started to develop their initial climate change adaptation policies.

> *"I had a student who did her master dissertation last year and she looked at every city council in the UK and what their adaptation plans were, and how far along they were and how many resources they had devoted to the adaptation and what she found out is that 90 percent of the city councils really have no adaptation plans whatsoever."*
>
> Respondent from Cambridge Centre for Climate Change

Another sub-theme of local policies was related to the lack of long-term planning for delivery of the sustainable modes of transport which makes it difficult to fund transport projects appropriately. It was also argued that the transport plans do not consider cyclists infrastructures at the initial phase of the design.

> *"The planned cycle routes throughout Cambridge and yet all of the building these new jobs are predicated on people walking and cycling to work to a large extent. So why is not there a joined up cycle plan? This is little bits of it for which we got a bit of funding here and a bit of funding there, but we should have a joined up one, so that we make it funding this big. We can fill it enough little chunk of the plan that we have."*
>
> Respondent from Cambridge City Council

> *"The highway plan is still in design to setting old fashion ways of providing access to roads for cars and that is actually rather anti-cycling, because you end up with this big road junctions."*

Respondent from Cambridge Cycling Campaign

A participant also commented on the requirement for improving the road surfacing materials to adapt road transport sector to a possible air temperature increase.

> *"That [increase in air temperature] is enough to change the roadways but because we don't build our roadways here to withstand 35 degree heat. Back in North Carolina, where I came from in the United States, we build our roads to withstand 45 degree heat".*

Respondent from Cambridge Centre for Climate Change

The third theme emphasised by Cambridge participants regarding policy making process was about the disconnection between transport and land use policies in the past. It was argued that the City Council and County Council are now working closely together to develop their local plans.

> *"In the current plan development round which is developing a Cambridge local plan 2014 and the South Cambridgeshire district local plan 2014, the county council is doing a transport plan at the same time. This is new. We didn't do that last time, 6 or 7 years ago."*

Ex-councilor of Cambridge City Council

> *"We do work very closely to highways authority, I did comment very recently on some work that county council were doing on transport strategies and that sort of things and they do consider climate change. … I think I would be honest in saying that more work need to be done from a local highways perspective."*

Climate change expert from Cambridge City Council

> *"To date, monitoring the implementation, certainly, of travel plans has been patchy to say the least, it's not being consistent, it's not being organised. Since the first April this year [2014] that's changed and every organisation is*

assessed by the transport assessment team at the county council, every development has now to sign up to say that they will be monitored. … That's a fantastic improvement. … That has happened in the past, but very inconsistently."

Respondent from Travel for Cambridgeshire Partnership

However, there were also some opposite views and doubts about the effectiveness of working relationship between City and County Councils.

"The fact that the highway authority and the planning authority are two different councils, does not make it easy and we get have to get on with it because that's the way it is."

Respondent from Cambridge City Council

"It's over a year ago now to set up to go back to an arrangement that joint two councils to do transport issues and it still hasn't met to understand it."

Local politician from Cambridge

4.7 Institutional Barriers for Climate Change Adaptation

This section presents the main institutional barriers the study participants mentioned in the interviews. This category involves a range of factors including transparency and accountability, participation and consultation and distribution of power and responsibilities.

4.7.1 What Are the Main Institutional Barriers for a Resilient Road Transport System In Belfast?

As discussed in Section 4.4 and Section 4.5, the role of politicians in the prioritisation and financing of transport projects was perceived as a major barrier in the process of a transparent decision making. A common concern among participants was that although the key elements for achieving the objectives of sustainable transport systems are available but political influence can hamper the effective and appropriate decision making process.

> *"The factors influencing decision are clear, that's sustainability, that's economics, that's environmental issues etc. The key to making things more transparent is that the decision based on the correct decision making process and not on the point of law and not on a political one."*
>
> Respondent from River Agency, Belfast

A lack of appropriate mechanism for transparency and accountability was perceived to be a major issue by 5 participants. They argue that an appropriate mechanism should have an independent advisory body within the decision making process to reduce the influence of politicians.

> *"We supported it [Climate Change Bill][45]. We did say yes we should adopt the climate change bill, but we should work within the independent advisory body the UK uses [Committee on Climate Change-CCC]. So let's not try to re-invent the wheel, but let's just replicate what they are doing in England."*
>
> Respondent from Freight Transport Association, Belfast

> *"The original purpose was that Transport NI would be an independent agency that would be responsible for translating high level policy objectives from DRD into meaningful operational standards for Translink[46]. I think if that would have been the case that would be the most transparent model."*
>
> Respondent from Northern Ireland Environment Link, Belfast

> *"You have an organization promoting climate change and that is called Climate NI. You can have consumer council. What you have is difficulty as lot*

[45] http://www.doeni.gov.uk/fta_response_northern_ireland_climate_change_bill_consultation.pdf

[46] http://www.niassembly.gov.uk/globalassets/documents/reports/regional-development/nia-80-11-15.pdf

> *of these so called accountable bodies that have authority to ask for clarity why decisions are made, are normally government appointments."*
>
> Respondent from Rivers Agency, Belfast

However, a participant emphasised on the role that public awareness can play in removing the political influence in the process of climate change adaptation. A lack of communities which support the climate change was perceived by him as a major issue.

> *"The world is building communities to accept the climate change is happening and advising them on course of actions that are available and the pros and cons of them and then letting them make their own decisions. … Ultimately you have got to convince the users of the transportation network, why you are doing such and such and then you will get policy and strategy implemented."*
>
> Respondent from Friends of the Earth, Belfast

Three participants raised their concerns regarding the lack of supportive working relationship within the planning authorities. Inordinate changes in the planning structure was perceived as a major issue by a private transport planner. A respondent from NIEL argues that since the NI Environment Link is Co-funded by the Department of the Environment, in practice they cannot criticise the department's policies and strategies. This issue again highlights the need for creation of independent organisations and communities which can motivate politicians towards sustainable thinking.

> *"Dealing with the planning service is now impossible. So if those guys are difficult to work with, they are getting information from Stormont. … I'm not trying to be overly critical, it is a fact. I have a scheme of a private developer … and you know in the 4 years that it has taken just far because of lack of decision making, the planning office has changed 4 times… and that just makes decisions very difficult on a broader level."*
>
> Respondent from SW consultancy, Belfast

> *"I think there is an expertise issue may be within the planning service and they are perhaps not equipped to deal with the complexities of what come in and that may be needs to be looked at."*
>
> Respondent from Belfast City Council

> *"We have to try to be careful of them (DOENI), we describe ourselves as critical friends and that's how we manage that relationship with them. But you have to get that join up rather than jumped up approach."*
>
> Respondent from NIEL, Belfast

A participant from Belfast City Council criticised the consultation process of transport projects.

> *"That consultation is one of the key areas. Before you make the decision you seek consultation and I think that is what happened in the A5 bypass that was pulled out last minute, consultation process wasn't robust enough and so it was pulled by the high court."*
>
> Respondent from Belfast City Council

The distribution of roles and responsibilities among the key actors at different levels in relation to transport and climate change-related policies was perceived as one of the most important factors in the effectiveness and efficiency of climate change adaptation process. In most interviews the reform of the local governments was at the heart of the discussion. The other important issues were the coordination between key actors at different (national, regional and local) levels. Since a considerable amount of the discussions was linked to other political-economic issues (as discussed previously in this chapter), this section focuses on the institutional challenges and opportunities for the effective and efficient implementation of climate change adaptation policies.

Participants from Belfast city council, academia and two respondents from private sectors were positive about the devolution of planning powers from the regional to the local level. It was emphasised that the public have more access to the local politicians, and devolving the planning powers to Belfast city council will increase the local accountability and consequently this can improve the consistency of decisions with local conditions and needs particularly in terms of land use planning and its integration with local transport plans.

> *"These local politicians are the most accessible to the public. So therefore there's a greater linkage between the public's view and local politician."*
>
> Respondent from Belfast City Council, Belfast

However, three participants argued that although Belfast City Council has fulfilled well its previous environmental responsibilities, they need to improve their capacity to deal with climate change impacts. On the other hand, it was argued that devolving the planning power to the local councils without devolving the transportation planning power can impede the local accountability.

> *"There is a level of maturity required to deliver, but it (transferring the power from central to local level) should improve the transparency of the decision making and make it more accountable."*
>
> Respondent from Rivers Agency, Belfast

Although, the dominant view regarding the performance of Belfast City Council on the environmental issues was positive, there was a number of critical viewpoints and concerns about the decentralisation of powers and responsibilities. The main critic was that Belfast is not large enough and the decentrilised approach can be a tremendous barrier to efficient and effective decision making. It was also argued that the existing centralised approach provides a better opportunity for the effective delivery of transport policies.

> *"It's about economy of scale. Belfast is not big enough for that. ... Road services are responsible for all of the road network. Translink are responsible*

for all public transport, so that should facilitate that decision-making process and progress on climate change a little better."

Respondent from University of Ulster, Belfast

"I think the big positive way we have here is the likes of Translink or one group, wherein Scotland has been fragmented over the last few decades and it is very hard to get a single transport strategy, whereas here there is actually an opportunity if we want to work together. I'm working with a lot of guys in Glasgow and Edinburgh. … I have been working with senior guys over there. When they spend time here, they thought it's a big opportunity."

Respondent from SW Consultancy, Belfast

A participant from the Friends of the Earth raised his concern about the transfer of powers from the central level to local level by emphasising on the lack of required expertise among local politicians and decision makers in making evidence based decisions. It was highlighted that due to the lack of expertise, local politicians are apt to make biased decisions.

"The people just making the decision, up the higher level, are being advised by policy makers, informed individuals based on evidence, scientific evidence, etc."

Respondent from Friends of the Earth, Belfast

Another concern was that the devolution of power and responsibilities from national/regional level to local level can bring more political influence on the decision making process. It was emphasised that the local governments in Northern Ireland need to improve the skills not only in terms of the delivery of policy decisions but also in terms of independent decision making in consistent with local needs and depart from the political influences.

> *"Local politics is the same as central politics. It is politically driven. There is a need for local politics to develop their skills in delivering, I would call, no political day-to-day matters."*
>
> Respondent from Rivers Agency, Belfast

However, a participant from NIEL (NI Environmental Link) was of the opinion that although devolution of power to the local level can bring more political influence in decision making process, as a result of improving the transparency and accountability, but politicians at different levels of governance can become more motivated to consider climate change and sustainability in their decision making process.

4.7.2 What Are the Main Institutional Barriers for a Resilient Road Transport System In Cambridge?

The dominant attitude regarding the transparency of transport decision making process in Cambridge was positive. It was argued that there are several opportunities for interest groups to follow transport agenda, consult and influence transport decisions. Two participants related people's concern about the transparency and accountability to the existence of two tier systems in Cambridge which makes it difficult for them to clearly understand the roles and distribution of each council.

> *"Local government is transparent, every decision can be viewed .... So, they have every opportunity to get stuck in. ... Then the consultation period comes. There is plenty of opportunity to influence".*
>
> Respondent from Cambridge City Council

> *"I think the average citizen would feel that this is not at all a transparent system but this is just because the average citizen doesn't know where you go to get the information here. If somebody wants to understand the policies here and the strategies, it's possible to see it entirely."*

Respondent from Cambridge Centre for Climate Change

"One of the simple political reasons for wanting to combine the two layers of councils is the average member of the public hasn't got a clear which council produces which service and this is complete confusion and if a member of public goes to the city council and say I don't like this, and they say it is not us, it is the county and this's terribly frustrating. … Some lampposts belong to the city and some belong to the county."

Ex-councilor of Cambridge City Council

There were two attitudes about the level of consultation of transport decisions and projects. The first and dominant viewpoint was that the consultation process with the county council is not robust. The supporters of this perspective argue that Cambridge City Council are more interested to consult with interest groups about different issues including climate change, sustainability and other environmental issues. But County Council consults on the issues only when there is a statute regarding the consultation.

"For major issues such as transport, climate change and so forth, city council turns to University of Cambridge academics quite a bit, so any time they do something with climate change over there, they come here to the climate change center and they want to know how their policy works and any time they are dealing with transport, they go to the department of engineering here in the university so we have a long history of interacting with the city council. … There's lot less connection with the county council."

Respondent from Cambridge Centre for Climate Change

"The city council tries to consult with the public … But the county council on the other hand when they were going to do something, they will go away and look at the law, do we have a statute to enforce us to consult on this, No! We

won't then. … What you do beyond what the law says is a matter of political choice."

Respondent from Cambridge City Council

"I think to some extent in the past there have been examples where the transport decision making in Cambridge has been driven by very personal interest of some of the people in the council either the councilors or the officers."

IPCC lead author from University of Cambridge

However, two participants from Cambridgeshire County Council argue that the consultation process is extensive and influential.

"We have committee process that we take things through, there's a consultation process everything goes through … which brings in that degree of accountability. Because it does allow anybody with an interest to get involved the process and respond to consultation. The transport strategy we are currently developing that's been subjected to some quite extensive public consultation".

Respondent from Cambridgeshire County Council

"There has been a considerable amount of lot of consultation recently trying to make it most cycle friendly on two of main roads. … It was very influential."

Respondent from Cambridgeshire County Council

Regarding the distribution of transport and planning powers at the local level, majority of participants argue that a single-tier model for the local government can lead to better integration of transport and land use policies at the local level and also can improve the accountability and transparency of local plans and decisions. However, there were two different attitudes regarding the appropriate scale for the local authority.

> *"Everybody knows that things like transport issues cannot be solved at small units, they have to be solved at much larger units, because all the city will do is to create a policy that works great inside the city and then causes terrible traffic problems for the people live out at the villages."*
>
> Respondent from Cambridge Centre for Climate Change

> *"There's always a feeling that somethings are better decided more locally."*
>
> Ex-councilor of Cambridge City Council

Participants raised their concerns that the political conflicts between the two councils, which are under different political party control, is the main barrier towards the creation of a new governance arrangement between the local councils.

> *"I think Cambridge city council is not eager to go into a unitary authority, because they think their sustainability plans will be diluted by inclusion in the unitary authority."*
>
> Respondent from Cambridge Centre for Climate Change

> *"There are strong view that the Cambridge area should have its own unitary council, well there's no government will to let that happen or to make that happen, because it will require some compromises".*
>
> Local politician from Cambridge

> *"A unitary authority would be the answer to dealing properly with the transport issues in the city, but the major stumbling block to having a unitary authority is the difficulty of knowing what to do with the rest of the county. We do not want a unitary authority that is county size. We already know that the interests of the city and the interest of the rural areas are different, particularly on transport actually. There are many occasions when a lot of the rural people said that the city is waging a war on the car, no, we are not!"*
>
> Respondent from Cambridge City Council

4.8 Conclusion

Although stakeholders in both cities considered the main impacts of climate change important but qualitative data analysis clearly shows that Belfast participants have not recognised increased air temperature as important as increased rainfall. It was frequently highlighted that the attention paid to the maintenance of existing roads and improving the sustainable modes of transport was not enough in the past. In addition, increased rainfall can be a major issue with the existing agenda and prioritisation plan. However, transport stakeholders in Cambridge divided their concerns almost equally between the increased air temperature and change in rainfall patterns.

Findings show that the overall progress on translating the national climate change adaptation objectives to the local actions is in its infancy. According to the discussions, it can be concluded that with an optimistic interpretation, Belfast has just started to initiate climate change adaptation policies at the national level and more efforts are required to move towards the implementation phase of the policy cycle. As an example, the Climate Change Bill which was due in 2012 has not been agreed yet. Participants in Cambridge raised a similar concern but to a lesser extent. Their main concern was related to neglecting the long-term impacts of climate change which potentially can make the existing effort non-effective.

Findings of this chapter show that transport stakeholders in two case studies, Belfast and Cambridge, are facing different challenges regarding the implementation and delivery of climate change and sustainable transport policies. Participants in Belfast underlined the lack of political will at the national/regional level followed by the inappropriate financing of transport projects and lack or inconsistency in policy documents with regards to climate change adaptation. However, Cambridge transport stakeholders emphasised on financial constraints at the local level and the ineffective integration of land-use and transport policies in the last decade.

Table 4-2 summarises findings of this chapter. These findings combined with findings from the literature review are used to design the Q methodology survey explained Chapter 5. Interview scripts were analysed and more than 200 Q concourses were created (see Chapter 3). Then each statement was tagged several times with the related themes and factors. 28 factors were extracted initially from the interview results which are shown in Table 4-2. This factors then were combined with literature review findings and 7 more factors were added to the list. Each of these 35 factors were converted to a Q statement considering the recommendations by scholars, such as avoiding double negative, focusing on single factor in each statement, clarity, etc. Chapter 5 will includes Q statements and analysis of Q sortings for each case study area.

Table 4-2: Summery of interview findings in Belfast and Cambridge

Theme	Belfast	Cambridge
Impacts of climate change		
High temperature	☑	☑☑☑
Extreme weather conditions	☑☑☑	☑☑
Sea level rise	☑☑	☑
Scientific barriers & Uncertainty		
Need for expert staff to deal with the impacts of climate change on the road transport system.	☑	☑☑
Need for national/regional level guidelines for integrating climate change policies into the larger sustainable urban transport framework.	☑☑	☑☑
Negative role of uncertainty in climate change adaptation	☑	☑☑
Need for local level climate change risk assessments	☑☑	☑☑☑
Socio-Political factors		
Scepticism of politicians on the existence and importance of climate change.	☑☑☑	☑
Lack of public demand and political will and support for climate change adaptation.	☑☑	☑☑
Decisions are more consistent with the attitudes of political parties, than addressing the actual needs of urban areas.	☑☑☑	☑☑

The tension between short-term electoral cycle and long-term nature of climate change has reduced the political will.	☑☑☑	☑☑
Local level actors can do better job in delivery of climate change adaptation policies than national/regional level departments.	☑☑	☑☑
Funding Mechanism and Financial Issues		
Disconnection between the national funding mechanism and sustainable transport policy objectives.	☑	☑☑
Lack of resources at the local level to recruit required climate change experts.	☑	☑☑☑
Need for higher priority to maintain the existing roads, rather than construction of new roads.	☑☑☑	☑
Need for more financial incentives, so transport authorities motivate to adapt the transport sector to climate change.	☑☑	☑☑☑
The existing financing mechanism permits decision makers to secure project approval and funding through under-estimating the long-term cost of the project.	☑	☑☑
Decision Making Process & Policy Barriers		
Lack of coordination between climate change and transport departments at the national/regional level.	☑☑☑	☑
Lack of coordination between climate change and transport departments at the local level.	☑	☑☑☑
Gap between the policy directives and actual practices.	☑☑	☑☑
The top-down decision-making about the climate change adaptation is resulting in inconsistent policies and implementation failure at the local level.	☑☑	☑☑
Very difficult to reach a consensus among different transport organisations at different levels.	☑☑	☑☑☑
Need to improve the transparency in the decision making process for transport investment.	☑	☑
Need for stakeholder participation in dealing with the uncertain impacts of climate change.	☑☑☑	☑☑
Politicians do not represent the opinions of stakeholders regarding the climate change policies.	☑	☑
Institutional Barriers for Climate Change Adaptation		
Unclear distribution of roles and responsibilities for dealing with climate change adaptation.	☑☑	☑
Lack of an effective leadership on climate change policy.	☑☑☑	☑☑
Devolving more transport power from national/regional level to local level accelerates the climate change adaptation process.	☑☑	☑

Chapter 5 - Q Methodology Findings

5.1 Introduction

Findings from the interviews in Chapter 4 highlighted the existence of different attitudes about the barriers against the implementation of climate change adaptation policies in road transport sector at the city level. The findings from Chapter 4 combined with the findings from the literature review are used to generate a representative set of statements regarding the process of climate change adaptation within the road transport sector. 35 statements are judged to be a comprehensive set of factors influencing this process. These statements form a manageable sample size for participants to sort. This chapter presents the findings of Q methodology conducted in two case study areas, Belfast and Cambridge. Study participants were recruited through email and follow up phone call. 21 participants from Belfast and 27 participants from Cambridge completed the Q sorting of the provided statements. All participants completed the survey online, except three participants from Cambridge who preferred to complete it on paper. These three participants self-completed the survey on a printed Q sorting sheet in researcher's presence. 7 participants from Belfast and 11 participants from Cambridge were attended to in-depth interviews (Chapter 4). Table 5-1 shows the split of respondents between organisations in Belfast and Cambridge case studies. It should be highlighted that a pilot study was conducted at Ulster University to investigate the clarity of statements before circulation of them to study participants.

Table 5-1: Q methodology survey participants

Case study city	Organisation	Number
Belfast	*University of Ulster*	4
	Queen's University Belfast	3
	Belfast city council	4
	Department for Regional Development (DRD)	2
	Department of Environment (DOE)	1
	Northern Ireland Environment Link (NIEL)	1
	Rivers Agency	1

Case study city	Organisation	Number
	Atkins *Freight Transport* *NI Cycling Initiatives* *Institute of Civil Engineering*	1 1 1 2
Cambridge	*Cambridge City Council* *Cambridge Centre for Climate Change* *Cambridgeshire County Council* *University of Cambridge* *Interest groups (former politicians/road users)* *Cambridge Cycling Campaign* *Travel for Cambridgeshire Partnership*	7 5 4 5 4 1 1

The initial data collected from online FlashQ application and three offline Q sorts was analysed using the Principle Component Analysis (PCA) method as a dimension reduction method followed by the Varimax Rotation function (see Chapter 3 for more detail about Q factor analysis). Then the final factors or in other words the main attitudes were extracted by determining the exemplifiers and calculation of the factor weights as explained in Chapter 3. Section 5.2 and section 5.3 present the findings for Belfast and Cambridge case studies respectively. Each section starts with a brief explanation about the Q factor analysis and followed by the description of four factors which have been extracted by using the Principle Component Analysis (PCA) and Varimax rotation functions. Section 4.8 involves the discussion and conclusion of this chapter which highlights the consensus and differences between supporters of those attitudes extracted from each case study area.

5.2 Belfast

21 participants from Belfast case study area involved in this phase of research. Collected data was analysed in SPSS and Microsoft Excel software tools. Data analysis shows that there are four distinct attitudes towards the implementation of climate change adaptation policies within the road transport sector in Belfast. Each of these four attitudes represents the viewpoint of at least four participants which confirms that appropriateness of the conducted Q factor analysis on the collected data.

Figure 5-1 shows the screen plot of the factors after the Principle Component Analysis (PCA) was conducted (but before Varimax rotation process). There were seven factors with an eigenvalue of greater than 1. For the purpose of factor rotation all seven factors were kept. It should be emphasised that the decision about the number of the factors is a judgment by researchers aiming to increase the total explained variance of the study (to keep the maximum possible amount of the collected data) and also to reduce the number of the extracted factors in order to be able to interpret the final factors. For the data collected in Belfast, it was decided that the four factor solution is the best solution since all participants (except P16) are significantly loaded on at least one of the extracted factors. In addition, each factor has at least four representative participants which is more than the minimum requirement of two. Furthermore, as shown in Table 5-2, the total explained variance of the study is 52.26% which is greater than the recommended value of 50% in Q literature.

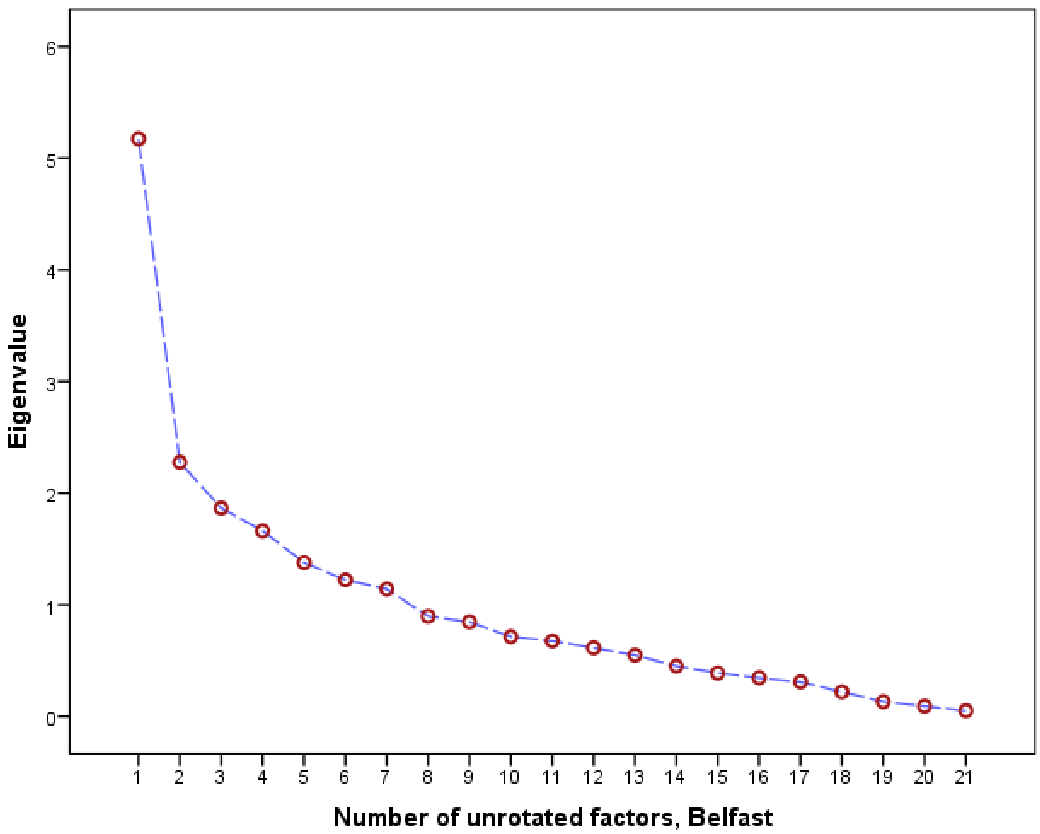


Figure 5-1: Screen plot of un-rotated factors in Belfast

Table 5-2: Total variance explained by four factor solution, Belfast

Fac	Initial Eigenvalues EV	Variance (%)	Cumulative Variance (%)	After Varimax Rotation EV	Variance (%)	Cumulative Variance (%)
1	5.171	24.626	24.626	3.336	15.886	15.886
2	2.276	10.837	35.463	3.155	15.023	30.910
3	1.865	8.882	44.345	2.276	10.837	41.747
4	1.662	7.912	**52.258**	2.207	10.511	52.258
5	1.377	6.557	58.815			
6	1.224	5.827	64.642			
7	1.141	5.433	70.074			
8	.898	4.275	74.349			
9	.846	4.027	78.376			
10	.713	3.397	81.773			
11	.676	3.218	84.990			
12	.614	2.923	87.913			
13	.550	2.621	90.534			
14	.451	2.147	92.681			
15	.388	1.850	94.530			
16	.345	1.644	96.175			
17	.309	1.469	97.644			
18	.220	1.046	98.690			
19	.132	.627	99.317			
20	.092	.440	99.757			
21	.051	.243	100.000			

Extraction Method: Principal Component Analysis.

As discussed in Chapter 3, equation $2.58/\sqrt{NS}$ can be used to determine the margin for Significant Loading Coefficient (SLC) where NS is the number of the statements (NS=35). In this study, the value of SLC is calculated as 0.436. Except one participant (P16) which cannot be effectively loaded on each of those four factors, the attitude of other participants can be represented by at least one of the factors. Table 5-3 shows the loading coefficients of all 21 participants on the four extracted factors after applying Varimax rotation function. Non-significant loading coefficients have not been shown in this table. However, there are three other participants which are confounded and have been loaded on more than one factor (here two factors). Table 5-3 shows the loading coefficients of 21 Q sorts on four extracted factors.

Table 5-3: Loading coefficients after Varimax rotation, Belfast

Participant	Factors			
	A	B	C	D
P12	.762			
P10	.725			
P7	.687			
P21	.670			
P1	.602			.540
P13	.500			
P16	Not loaded on any of factors			
P9		.705		
P19		.700		
P11		.649		
P14		.607		
P3		.574		
P15		.498		
P6			.692	
P18			.674	
P8			.556	
P17		.463	.549	
P4				.701
P2				.604
P20				.567
P5				-.476

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax

As discussed in Chapter 3, Q methodology literature provides us with different recommendations regarding the involvement of confounded Q sorts. However, in this study, it was decided not to include confounded Q sorts in the estimation of final factor since each factor will represent a unique perspective towards the implementation of climate change adaptation policies. Those confounded Q sorts can generate mixed attitudes towards the topic of the study. Even after removing those confounded Q sorts, the minimum number of remaining Q sorts for factor estimation will be three (for factor C) which is still greater than the minimum required value which is two. Finally, it should be emphasised that although in mathematical languages there are four Eigen Vectors (factors), since there is a negative significant loading (P5 over factor D), but in practice there are five factors which explain 52% of total variance of the study in Belfast.

The final estimation of the factors for the purpose of the interpretation of final scores was conducted using the factor weights and Z-scores as explained in detail in Appendix A-1. Table 5-4 shows the final scores for each statement from each factor view point. Scores for each factor have been calculated using the average scores of the exemplifiers of that factor. The following sections discuss the highlighted variables for the implementation of the climate change adaptation policies in road transport sector; these discussions are coming from the supporters of each of the extracted factors.

Table 5-4: Factor scores for Belfast

No	Statement	A	B	C	D
1	Roles and responsibilities for climate change adaptation are not clear across levels of government	-1	0	3	1
2	Roles and responsibilities for climate change adaptation are not clear between the public and private sector.	0	2	-3	0
3	An effective leadership on climate change policy is lacking at the national level.	1	3	0	1
4	An effective leadership on climate change policy is lacking at the local level.	-3	-1	1	3
5	There is a lack of coordination between climate change and transport departments at the national/regional level.	0	0	3	2
6	There is a lack of coordination between climate change and transport departments at the local level.	1	0	-1	-2
7	Current transport governance arrangements are unsatisfactory for delivery of climate change adaptation policies and strategies.	3	-1	-1	-2
8	Devolving transport power from national/regional level to local level accelerates the climate change adaptation process.	-3	-2	2	2

No	Statement	A	B	C	D
9	There is a disconnection between the current national funding mechanism and sustainable transport policy objectives.	0	2	0	1
10	Local transport authorities have adequate resources to recruit required climate change experts.	-1	-2	2	1
11	Local transport authorities have adequate expert staff to deal with the impacts of climate change on the road transport system.	-2	3	0	-3
12	Government should give higher priority to adapt road users and existing transport infrastructures to the climate change rather than construction of new infrastructure.	1	0	2	2
13	Transport-related decisions are made by the authority with implementation power rather than reaching a consensus jointly with other stakeholders on conflicting issues.	3	-2	-2	2
14	There are not enough guidelines for integrating climate change policies into the larger sustainable urban transport framework.	1	1	1	-1
15	There are not enough guidelines for transport decision makers to deal with an uncertain climate future.	3	0	0	-1
16	Financial benefits of the climate change adaptation cannot persuade politicians to implement the climate change adaptation policies.	2	-2	1	3
17	There is discretionary power for the local/regional level actors to prioritise the implementation of the transport projects.	1	1	0	-1
18	The scepticism of politicians on the existence and importance of climate change are a significant barrier in the way of effective climate change adaptation.	1	2	-3	-3
19	Local/regional authorities should give higher priority to climate change on their agenda.	-1	2	-2	-2
20	A lack of political will and support has slowed down the process of climate change adaptation.	2	1	1	-1
21	Climate change adaptation policies are mostly incorporated into transport policies, but there is a gap between the policy directives and actual practices.	-2	1	1	0

No	Statement	A	B	C	D
22	The top-down decision-making about the climate change adaptation is resulting in inconsistent policies and implementation failure at the local level.	2	1	-3	0
23	It is very difficult to reach a consensus among different transport organisations at different levels regarding transport issues.	2	0	-2	-2
24	Transport authorities' decisions are more consistent with the attitudes of their political parties, than addressing the actual needs of urban areas.	2	0	-1	0
25	There is a clear need to improve the transparency in the decision making process for transport investment.	-2	-1	0	1
26	Current transport arrangements offer adequate participation for stakeholders, interest groups and academia in dealing with the uncertain impacts of climate change.	-1	2	2	-3
27	Direct stakeholder participation is not beneficial, since the politicians themselves represent the opinions of stakeholders.	-1	-1	-1	-1
28	Adequate financial incentives are available for transport authorities to adapt the transport sector to climate change.	-2	-2	3	0
29	There is not sufficient public demand for climate change adaptation.	0	3	-1	2
30	The tension between short-term electoral cycle and long-term nature of climate change has reduced the political will.	0	-3	-2	3
31	The uncertain climate change risk assessment has challenged the process of decision making.	-2	1	-2	-2
32	For the purpose of evaluation and monitoring, there are adequate information and guidelines available about the climate change and adaptation measures at the local level.	-1	-3	0	-1
33	The existing financing mechanism permits decision makers to secure project approval and funding through under-estimating the long-term cost of the project.	0	-1	1	1
34	Current climate change adaptation activities in the transport sector are mostly proactive.	0	-3	-1	0

No	Statement	A	B	C	D
35	Devolution of transport powers, from the national/regional level to the local level, increases the degree of political influence on decisions.	-3	-1	2	0

It is important to emphasis that although, in theory, factor analysis generates distinct factors which do not correlate with each other (Correlation =0) since those initial factor loadings are converted to factor scores for a better interpretation, the correlation coefficients between every two factors will not be zero. However, it is expected to have a week correlation coefficients between these extracted factors. Table 5-5 checks this criteria and confirms that the maximum correlation between these four factors is 0.406 which is less than SLC=0.436.

Table 5-5: Correlations between factors

	A	B	C	D
A	1.000	0.075	-0.387	-0.085
B	0.075	1.000	-0.208	-0.406
C	-0.387	-0.208	1.000	0.125
D	-0.085	-0.406	0.125	1.000

The following sections discuss each factor separately to find out the main concerns of the supporters of each factor.

5.2.1 Factor A: Need for Political Support and Better Consultation

Factor A represents the viewpoint of six study participants which is more than 28% of P-set, though one of the participants loaded on this factor is confounded between factor A and factor C. Total explained variance by factor A, after applying Varimax rotation, is 15.88%.

As shown in Figure 5-2, Statements S4, S8 and S35 have a score of -3 in this factor. On the other hand, this factor gives a score of +3 to statements S7, S13 and S15. From the factor A viewpoint, although the existing top-down transport governance arrangements are not satisfactory for the implementation of climate change adaptation policies (S7, S22) but the main barriers in the process of a climate-resilient transport system is due to the lack of the effective consultation and participation of stakeholders on conflicting issues (S13, S23, S26, S27). Participants who support this attitude have blamed the lack of political will and supports towards climate change adaptation (S16, S20, S24) and also blamed the financial constrains at the national/regional levels (S28). This attitude does not consider the scientific barriers important for the process of climate change adaptation (S31). The lack of integration between transport and climate change policies and the lack of adequate climate change expertise were emphasised to be the main barriers for the local stakeholders (S11, S21).

Institutional factors received little attention from the supporters of this attitude. Clarity in the distribution of roles and responsibilities regarding climate change adaptation at the local and national level received a neutral score (0 and -1 respectively) (S1, S2). In addition, this attitude sees the existing transparency in the decision making process of transport investments to be adequate (S25). Raising awareness about climate change for both the public and politicians was not a significant factor in this attitude (S29) although politicians' scepticism about climate change and its impacts gained a score of +1 (S18). Moreover, the funding mechanism of transport projects was not considered to be either effective or ineffective. As mentioned above, this attitude demands a transparent funding process (S25) although it is not clear that whether there is an integrated and long-term financing mechanism for achieving the objectives of sustainable transport (S9). To summarise, factor A puts different emphasis on different issues with more greater emphasis on the requirement for effective consultation and participation, a medium emphasis on political will and support and less emphasis on funding mechanism and transparency of decision making process.

(-3)	(-2)	(-1)	0	(+1)	(+2)	(+3)
An effective leadership on climate change policy is lacking at the local level.	Local transport authorities have adequate expert staff to deal with the impacts of climate change on the road transport system.	Roles and responsibilities for climate change adaptation are not clear across levels of government	Roles and responsibilities for climate change adaptation are not clear between the public and private sector.	There is a lack of coordination between climate change and transport departments at the local level.	Financial benefits of the climate change adaptation cannot persuade politicians to implement the climate change adaptation policies.	Current transport governance arrangements are unsatisfactory for delivery of climate change adaptation policies and strategies
Devolving transport power from national/regional level to local level accelerates the climate change adaptation process.	Climate change adaptation policies are mostly incorporated into transport policies, but there is a gap between the policy directives and actual practices.	Local transport authorities have adequate resources to recruit required climate change experts.	There is a lack of coordination between climate change and transport departments at the national/regional level.	Government should give higher priority to adapt road users and existing transport infrastructures to the climate change rather than construction of new infrastructure.	A lack of political will and support has slowed down the process of climate change adaptation.	Transport-related decisions are made by the authority with implementation power rather than reaching a consensus jointly with other stakeholders on conflicting issues.
Devolution of transport powers, from the national/regional level to the local level, increases the degree of political influence on decisions.	There is a clear need to improve the transparency in the decision making process for transport investment.	Local/regional authorities should give higher priority to climate change on their agenda.	There is a disconnection between the current national funding mechanism and sustainable transport policy objectives.	There are not enough guidelines for integrating climate change policies into the larger sustainable urban transport framework.	The top-down decision-making about the climate change adaptation is resulting in inconsistent policies and implementation failure at the local level.	There are not enough guidelines for transport decision makers to deal with an uncertain climate future.
	Adequate financial incentives are available for transport authorities to adapt the transport sector to climate change.	Current transport arrangements offer adequate participation for stakeholders, interest groups and academia in dealing with the uncertain impacts of climate change.	There is not sufficient public demand for climate change adaptation.	There is discretionary power for the local/regional level actors to prioritise the implementation of the transport projects.	It is very difficult to reach a consensus among different transport organisations at different levels regarding transport issues.	
	The uncertain climate change risk assessment has challenged the process of decision making.	Direct stakeholder participation is not beneficial, since the politicians themselves represent the opinions of stakeholders.	The tension between short-term electoral cycle and long-term nature of climate change has reduced the political will.	The scepticism of politicians on the existence and importance of climate change are a significant barrier in the way of effective climate change adaptation.	Transport authorities' decisions are more consistent with the attitudes of their political parties, than addressing the actual needs of urban areas.	
		For the purpose of evaluation and monitoring, there are adequate information and guidelines available about the climate change and adaptation measures at the local level.	The existing financing mechanism permits decision makers to secure project approval and funding through under-estimating the long-term cost of the project.	There is a lack of coordination between climate change and transport departments at the local level.		
			Current climate change adaptation activities in the transport sector are mostly proactive.			

Figure 5-2: Average Q Sort for factor A, Belfast

5.2.2 Factor B: Lack of Financial Recourse and Expertise

Seven participants (6 pure loading and 1 confounded loading) were loaded significantly on factor B which explains more than 15% of total variance of the study.

As shown in Figure 5-3, this attitude emphasises on statements S3, S11 and S29 by giving a score of +3 and neglects the importance of statements S30, S32 and S34 by assigning a score of -3 to them. Lack of leadership on climate change adaptation at the national level was considered to be a significant barrier for the implementation of climate change adaptation policies (S3). The supporters of this attitude are of the opinion that the current climate change adaptation activities in road transport sector are mostly proactive (S34). In addition, among four extracted factors this attitude has given a neutral score (0) to the need for giving a higher priority to adapting the existing transport infrastructure to climate change. On the other hand, it has given the biggest figure to the construction of new infrastructure (S12). Similar to factor A, this attitude is critical of the devolution of transport power and responsibilities from national/regional level to the local level (S8). This viewpoint rejects that transport-related decisions are not made by reaching a consensus jointly with stakeholders (S13), and accepts that the existing governance arrangements offer a satisfactory condition for the participation of stakeholders, interest group and academia in dealing with climate change issues (S23, S26).

Although this attitude considers the lack of sufficient public demand for climate change adaptation and the skepticism of politicians on the importance of climate change (S18, S29) as the main barriers but it has put less emphasis on political factors including political will and supports (S20, S30) than other three factors. For example, Factor B is the only attitude that gives a negative score to statement 16. This attitude claims that the transport authorities have not paid sufficient attention to climate change adaptation during developing the local/regional transport plans (S19). At the same time, it puts emphasis on the lack of guidelines for climate change adaptation and possible measures for the transport sector which consequently hampers the monitoring process of policy development and implementation (S32). This issue has been related to the lack of financial resources and incentives for both recruiting required climate change adaptation experts (S10) and also for the integration of climate change adaptation policies within transport decisions (S28).

In contrast with factor A, this attitude does not consider the existing participation and consultation process to be a negative factor for the implementation of climate change adaptation policies (S13, S26). In addition, this attitude is the only attitude that rejects the lack of expertise among transport authorities as a barrier in dealing with climate change impacts (S11) although it is the only attitude that has given a positive score to statement 31 which is related to the impact of uncertainty on the effective decision making about climate change. Like factor A, in this attitude, the issue of coordination between different departments at different levels has not received either positive or negative score (S5, S6). However, this attitude is the only attitude which claims that the distribution of roles and responsibilities among public and private organisations are not clear enough (S2).

To summarise, this attitude is optimistic about the existing progress on the implementation of climate change adaptation and sustainable transport policies. In addition, political will and support have not been recognised as a significant barrier against introducing a resilient transport system in Belfast. The focus of this attitude is on financial incentives for transport decision makers to recruit required experts for adapting road transport sector to climate change impacts. Similar to factor A, institutional factors including the transparency of transport decisions were not recognised as an influential factor in comparison to financial constraints.

(-3)	(-2)	(-1)	0	(+1)	(+2)	(+3)
The tension between short-term electoral cycle and long-term nature of climate change has reduced the political will.	Devolving transport power from national/regional level to local level accelerates the climate change adaptation process.	An effective leadership on climate change policy is lacking at the local level.	Roles and responsibilities for climate change adaptation are not clear across levels of government	There are not enough guidelines for integrating climate change policies into the larger sustainable urban transport framework.	Roles and responsibilities for climate change adaptation are not clear between the public and private sector.	An effective leadership on climate change policy is lacking at the national level.
For the purpose of evaluation and monitoring, there are adequate information and guidelines available about the climate change and adaptation measures at the local level.	Local transport authorities have adequate resources to recruit required climate change experts.	Current transport governance arrangements are unsatisfactory for delivery of climate change adaptation policies and strategies	There is a lack of coordination between climate change and transport departments at the national/regional level.	There is discretionary power for the local/regional level actors to prioritise the implementation of the transport projects.	There is a disconnection between the current national funding mechanism and sustainable transport policy objectives.	Local transport authorities have adequate expert staff to deal with the impacts of climate change on the road transport system.
Current climate change adaptation activities in the transport sector are mostly proactive.	Transport-related decisions are made by the authority with implementation power rather than reaching a consensus jointly with other stakeholders on conflicting issues.	There is a clear need to improve the transparency in the decision making process for transport investment.	There is a lack of coordination between climate change and transport departments at the local level.	A lack of political will and support has slowed down the process of climate change adaptation.	The scepticism of politicians on the existence and importance of climate change are a significant barrier in the way of effective climate change adaptation.	There is not sufficient public demand for climate change adaptation.
	Financial benefits of the climate change adaptation cannot persuade politicians to implement the climate change adaptation policies.	Direct stakeholder participation is not beneficial, since the politicians themselves represent the opinions of stakeholders.	Government should give higher priority to adapt road users and existing transport infrastructures to the climate change rather than construction of new infrastructure.	Climate change adaptation policies are mostly incorporated into transport policies, but there is a gap between the policy directives and actual practices.	Local/regional authorities should give higher priority to climate change on their agenda.	
	Adequate financial incentives are available for transport authorities to adapt the transport sector to climate change.	The existing financing mechanism permits decision makers to secure project approval and funding through under-estimating the long-term cost of the project.	There are not enough guidelines for transport decision makers to deal with an uncertain climate future.	The top-down decision-making about the climate change adaptation is resulting in inconsistent policies and implementation failure at the local level.	Current transport arrangements offer adequate participation for stakeholders, interest groups and academia in dealing with the uncertain impacts of climate change.	
		Devolution of transport powers, from the national/regional level to the local level, increases the degree of political influence on decisions.	It is very difficult to reach a consensus among different transport organisations at different levels regarding transport issues.	The uncertain climate change risk assessment has challenged the process of decision making.		
			Transport authorities' decisions are more consistent with the attitudes of their political parties, than addressing the actual needs of urban areas.			

Figure 5-3: Average Q Sort for factor B, Belfast

5.2.3 Factor C: Need for Giving Higher Priority to Sustainable Transport

Factor C represents 10.84% of total variance of the study and 20.74% of the remaining variance. Four participants were significantly loaded with this factor which is more than 19% of the P-set.

The main emphasis in this attitude is on institutional factors such as the coordination between transport and climate change departments, DRD and DOE (S5) and the unclear distribution of roles and responsibilities between these departments regarding climate change adaptation policies (S1). However, there were contradictory scores for other institutional issues which show that those participants who are represented by factor C are not pessimistic about the existing transport governance arrangements for the delivery of climate change adaptation policies. This attitude claims that the existing mechanism offer an appropriate level of consultation and participation of stakeholders in the process of transport decision making (S26), reaching a consensus between different organisations about transport issues is not difficult (S23) and transport authorities have used consultation approach in decision making process rather than using their implementation power (S13).

This attitude is critical of top-down decision making method about climate change adaptation (S22) however it confirms that the devolution of transport powers and responsibilities from the national/regional level to the local level can accelerate the process of policy implementation (S8) although it can increase the political influence on decisions (S35). This contradictory opinion can be justified by considering the findings from Chapter 4. It was emphasised that the Belfast City Council has had an acceptable level progress towards the implementation of environmental-related policies such as recycling of wastes.

This attitude rejects the negative role of politicians in the implementation and delivery of climate change adaptation policies within transport sector (S24). Unlike Factor A and Factor B, which give positive figures to statement 18 (skepticism of politicians about climate change), Factor C strongly disagrees with this statement by giving a score of '-3'. Similarly, this attitude does not recognise the short-term electoral cycle of politicians as a significant barrier to the implementation of climate change adaptation policies (S30). Factor C is the only attitude among the four extracted factors that has given a negative score to statement 29, and accepts that there is a sufficient public demand for climate change adaptation. Interestingly, this attitude is the only factor that gives a negative score to statement 2 and accepts that the distribution of roles and responsibilities are clear between the public and private sectors. This can be justified by considering this attitude's score to the uncertainty of climate change (S2). This factor has given a score of '-2' to the negative role of uncertainty in the delivery of climate change adaptation policies, hence in this attitude it is justifiable that the distribution of roles and responsibilities among different organisations are clear.

This attitude does not see financial issues as important as institutional barriers at the local and national/regional levels. This attitude strongly agrees that required financial resources are available for transport authorities to adapt the road transport sector to the impacts of climate change (S28). But to a lesser extent, it was agreed that authorities at the local level have financial resources to recruit required climate change experts (S10). Regarding economic dimension, the main emphasis of the supporters of this attitude is on the prioritisation between construction of new infrastructures and adapting the existing infrastructures to future changes. It was agreed that the government should give a higher priority to the implementation of sustainable transport measures rather than constructing new roads (S12). However, the scores given to statements S12 and S19 show that in this attitude (and also factor D) there is a big gap between sustainable transport and climate change adaptation policies. It can be concluded that in this attitude, although attention to the implementation of sustainable transport objectives and policies is important but climate change does not have a significant impact in the success or failure of those policies.

(-3)	(-2)	(-1)	0	(+1)	(+2)	(+3)
Roles and responsibilities for climate change adaptation are not clear between the public and private sector.	Transport-related decisions are made by the authority with implementation power rather than reaching a consensus jointly with other stakeholders on conflicting issues.	There is a lack of coordination between climate change and transport departments at the local level.	An effective leadership on climate change policy is lacking at the national level.	An effective leadership on climate change policy is lacking at the local level.	Devolving transport power from national/regional level to local level accelerates the climate change adaptation process.	Roles and responsibilities for climate change adaptation are not clear across levels of government
The scepticism of politicians on the existence and importance of climate change are a significant barrier in the way of effective climate change adaptation.	Local/regional authorities should give higher priority to climate change on their agenda.	Current transport governance arrangements are unsatisfactory for delivery of climate change adaptation policies and strategies	There is a disconnection between the current national funding mechanism and sustainable transport policy objectives.	There are not enough guidelines for integrating climate change policies into the larger sustainable urban transport framework.	Local transport authorities have adequate resources to recruit required climate change experts.	There is a lack of coordination between climate change and transport departments at the national/regional level.
The top-down decision-making about the climate change adaptation is resulting in inconsistent policies and implementation failure at the local level.	It is very difficult to reach a consensus among different transport organisations at different levels regarding transport issues.	Transport authorities' decisions are more consistent with the attitudes of their political parties, than addressing the actual needs of urban areas.	Local transport authorities have adequate expert staff to deal with the impacts of climate change on the road transport system.	Financial benefits of the climate change adaptation cannot persuade politicians to implement the climate change adaptation policies.	Government should give higher priority to adapt road users and existing transport infrastructures to the climate change rather than construction of new infrastructure.	Adequate financial incentives are available for transport authorities to adapt the transport sector to climate change.
	The tension between short-term electoral cycle and long-term nature of climate change has reduced the political will.	Direct stakeholder participation is not beneficial, since the politicians themselves represent the opinions of stakeholders.	There are not enough guidelines for transport decision makers to deal with an uncertain climate future.	A lack of political will and support has slowed down the process of climate change adaptation.	Current transport arrangements offer adequate participation for stakeholders, interest groups and academia in dealing with the uncertain impacts of climate change.	
	The uncertain climate change risk assessment has challenged the process of decision making.	There is not sufficient public demand for climate change adaptation.	There is discretionary power for the local/regional level actors to prioritise the implementation of the transport projects.	Climate change adaptation policies are mostly incorporated into transport policies, but there is a gap between the policy directives and actual practices.	Devolution of transport powers, from the national/regional level to the local level, increases the degree of political influence on decisions.	
		Current climate change adaptation activities in the transport sector are mostly proactive.	There is a clear need to improve the transparency in the decision making process for transport investment.	The existing financing mechanism permits decision makers to secure project approval and funding through under-estimating the long-term cost of the project.		
			For the purpose of evaluation and monitoring, there are adequate information and guidelines available about the climate change and adaptation measures at the local level.			

Figure 5-4: Average Q Sort for factor C

5.2.4 Factor D: Need for Awareness Raising Activities

This attitude represents 10.51% of the total viewpoints about the study which is more than 20% of the remaining opinions after factor analysis. Five participants were significantly loaded on this factor but one of them is confounded between this attitude and Factor A. One of the participants (P5) was negatively loaded on this factor.

The emphasis of the supporters of this attitude has been put on the nature of climate change. It has been highlighted that politicians' viewpoint regarding the actions against climate change through adaptation is not negative but the long-term nature of climate change has reduced the political support due to the short-term electoral cycles (S30). This attitude strongly rejects the existence of the skepticism of politicians on the significance of climate change (S18), but it highlights the importance of short-term financial incentives for climate change adaptation to persuade politicians to act against climate change (S16).

In this attitude, institutional factors are determined to be the second most important set of barriers against the delivery of climate change adaptation policies within road transport governance. Supporters of this attitude are of the common opinion that the coordination between transport and climate change departments at the national/regional level is lacking (S5). Factor D is the only attitude that recognises the importance of effective leadership by giving the maximum possible score of +3 (S4). This attitude is the only factor that gives a score of +3 to statement 26 and critics the lack of adequate participation of stakeholders and interest groups in decision making process. Similarly, it has been agreed (score = +2) that transport-related decisions are not made by reaching a consensus with stakeholders but those decisions are made by authorities that have implementation powers (S13). For this attitude, reaching consensus regarding transport decisions is not a difficult process if the participation process is improved (S23, S26). Participants who have been loaded on this factor are of the common opinion that transport authorities do not have adequate expert staff to deal with the uncertainty of climate change (S26, S11).

Participants who are loaded on this attitude, do not agree that the existing transport governance is unsatisfactory in delivery of climate change adaptation policies (S7, S22). However, at the same time, the supporters of this attitude are optimistic about the positive role of devolution of transport power from regional to the local level in the efficient delivery of climate change adaptation policies (S8). This attitude does not recognise that this power devolution process can increase the political influence on transport decisions (S35). It can be justified by a positive score (+1) which is given to the need for improving the transparency for transport investment by the supporters of factor D (S25).

Scientific barriers including the existence of uncertainty on climate change or the lack of enough guidelines to integrate climate change adaptation policies were not highlighted by this attitude unlike other political or institutional factors (S31, S14). This issue cannot be linked to the use of forced distribution sheet in Q-methodology. This can be confirmed by paying a comprehensive attention to the scores given to different statements in this factor. As highlighted above, political factors are playing an important role in the implementation of climate change adaptation policies (S30). But this attitude related the issue to the lack of incentives for politicians to give a higher priority to climate change in their agenda (S28, S16) not to their skepticism about the existence of climate change (S18). It can be concluded that the science about climate change has delivered its message to politicians; however, in the context of political-scientific barriers, the lack of public demand for climate change adaptation (S29) is hampering the process of climate change adaptation.

(-3)	(-2)	(-1)	0	(+1)	(+2)	(+3)
Local transport authorities have adequate expert staff to deal with the impacts of climate change on the road transport system.	There is a lack of coordination between climate change and transport departments at the local level.	There are not enough guidelines for integrating climate change policies into the larger sustainable urban transport framework.	Roles and responsibilities for climate change adaptation are not clear between the public and private sector.	Roles and responsibilities for climate change adaptation are not clear across levels of government	There is a lack of coordination between climate change and transport departments at the national/regional level.	An effective leadership on climate change policy is lacking at the local level.
Current transport arrangements offer adequate participation for stakeholders, interest groups and academia in dealing with the uncertain impacts of climate change.	Current transport governance arrangements are unsatisfactory for delivery of climate change adaptation policies and strategies	There are not enough guidelines for transport decision makers to deal with an uncertain climate future.	Climate change adaptation policies are mostly incorporated into transport policies, but there is a gap between the policy directives and actual practices.	An effective leadership on climate change policy is lacking at the national level.	Devolving transport power from national/regional level to local level accelerates the climate change adaptation process.	Financial benefits of the climate change adaptation cannot persuade politicians to implement the climate change adaptation policies.
The scepticism of politicians on the existence and importance of climate change are a significant barrier in the way of effective climate change adaptation.	Local/regional authorities should give higher priority to climate change on their agenda.	There is discretionary power for the local/regional level actors to prioritise the implementation of the transport projects.	The top-down decision-making about the climate change adaptation is resulting in inconsistent policies and implementation failure at the local level.	There is a disconnection between the current national funding mechanism and sustainable transport policy objectives.	Government should give higher priority to adapt road users and existing transport infrastructures to the climate change rather than construction of new infrastructure.	The tension between short-term electoral cycle and long-term nature of climate change has reduced the political will.
	It is very difficult to reach a consensus among different transport organisations at different levels regarding transport issues.	A lack of political will and support has slowed down the process of climate change adaptation.	Transport authorities' decisions are more consistent with the attitudes of their political parties, than addressing the actual needs of urban areas.	Local transport authorities have adequate resources to recruit required climate change experts.	Transport-related decisions are made by the authority with implementation power rather than reaching a consensus jointly with other stakeholders on conflicting issues.	
	The uncertain climate change risk assessment has challenged the process of decision making.	Direct stakeholder participation is not beneficial, since the politicians themselves represent the opinions of stakeholders.	Adequate financial incentives are available for transport authorities to adapt the transport sector to climate change.	There is a clear need to improve the transparency in the decision making process for transport investment.	There is not sufficient public demand for climate change adaptation.	
		For the purpose of evaluation and monitoring, there are adequate information and guidelines available about the climate change and adaptation measures at the local level.	Current climate change adaptation activities in the transport sector are mostly proactive.	The existing financing mechanism permits decision makers to secure project approval and funding through under-estimating the long-term cost of the project.		
			Devolution of transport powers, from the national/regional level to the local level, increases the degree of political influence on decisions.			

Figure 5-5: Average Q Sort for factor D, Belfast

5.3 Cambridge

This section presents the findings from the Q-methodology conducted in the Cambridge case study by involving 27 participants representing views of the public and private organisations, politicians and other interest groups. The average Spearman correlation between all 27 Q-sorts is 25.01% which is larger than the 20% threshold of random Q-sorting discussed in Chapter 3. For the purpose of Q-factor analysis, three, four and five factor solutions were performed. The final factor scores showed that, similar to Belfast, a four factor solution is the best solution considering the number of significant loadings of participants on extracted factors as well as the total explained variance of the study. Figure 5-6 shows the eigenvalues (EV) of the extracted factors before the Varimax rotation function is undertaken. This figure shows that there are nine factors with EV>1. However, for the purpose of data interpretation only four factors are selected for the factor rotation purpose.

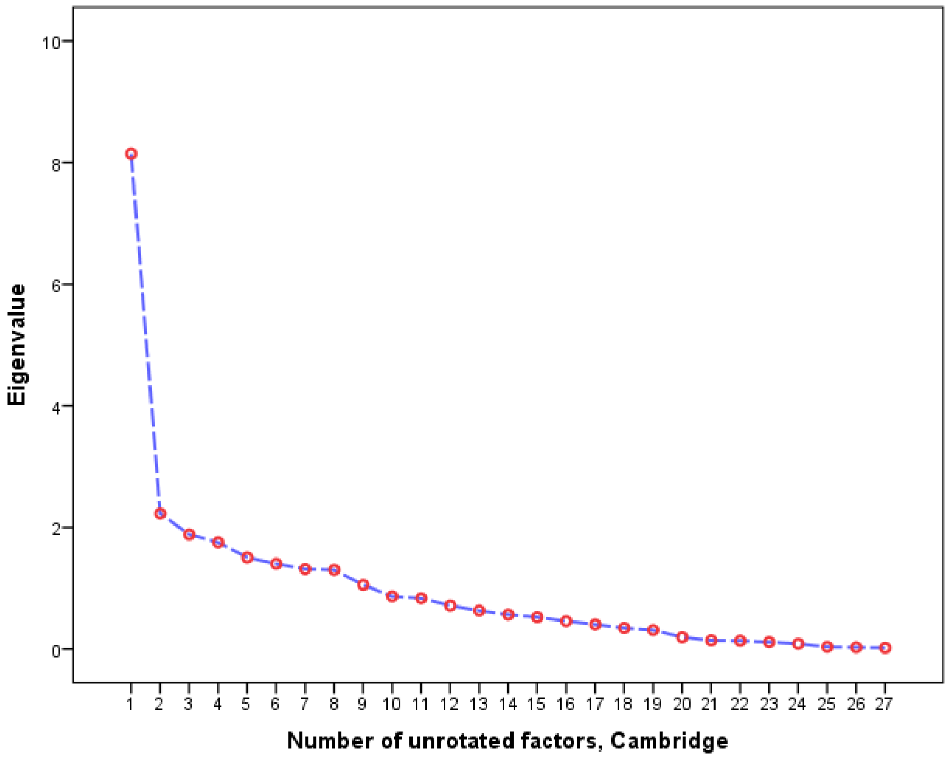


Figure 5-6: Screen plot of unrotated factors in Cambridge

Table 5-6 compared the EVs of extracted factors before and after performing the Varimax rotation function. As shown in this table and as discussed in Chapter 3, the Varimax rotation has not changed the total explained variance of the study (in four factor solution), it just rotates the factors to maximise the number of significant loadings on the extracted factors (see Table 5-7) and balances the existing difference between EVs of different factors extracted from the Principle Component Analysis (PCA). The four-factor solution in this Q–study explains about 52% of total variance which is greater than the recommended value of 50% in Q literature (see Chapter 3).

Table 5-6: Total variance explained by four factor solution, Cambridge

	Initial Eigenvalues			After Varimax rotation		
Fac	EV	Variance (%)	Cumulative Variance (%)	EV	Variance (%)	Cumulative Variance (%)
1	8.146	30.170	30.170	4.710	17.444	17.444
2	2.228	8.253	38.423	3.717	13.767	31.211
3	1.883	6.973	45.396	3.570	13.222	44.433
4	1.754	6.496	**51.892**	2.014	7.459	51.892
5	1.505	5.574	57.466			
6	1.402	5.191	62.658			
7	1.315	4.871	67.529			
8	1.302	4.823	72.352			
9	1.056	3.910	76.262			
10	.865	3.204	79.465			
11	.834	3.090	82.556			
12	.713	2.642	85.197			
13	.632	2.339	87.537			
14	.566	2.097	89.634			
15	.524	1.941	91.575			
16	.459	1.700	93.275			
17	.405	1.500	94.775			
18	.345	1.279	96.054			
19	.310	1.149	97.203			
20	.194	.720	97.923			
21	.142	.525	98.448			
22	.136	.502	98.950			
23	.114	.423	99.373			
24	.087	.323	99.697			
25	.036	.132	99.829			
26	.027	.100	99.929			
27	.019	.071	100.000			

Extraction Method: Principal Component Analysis.

Table 5-7: Loading coefficients after Varimax rotation, Cambridge

Participant	Factors A	B	C	D
P7	.831			
P21	.768			
P5	.723			
P18	.561			
P10	.560			
P3	.557			
P2	.554			
P25	Not loaded on any of factors			
P8		.744		
P4		.739		
P1		.738		
P27		.586		
P6		.585		
P11		.447		
P24			.579	
P19			.560	
P15			.559	
P26			.554	
P12			.533	
P23			.509	
P9	.477		.493	
P16			.488	
P13			.454	
P17			.446	
P22	.462			-.711
P14				.585
P20				.537

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax.

According to Table 5-7, only one participant (P5) was not significantly loaded on any of those four extracted factors. Two participants are confounded between two factors (P9 and P22). Similar to the Belfast study, there is also one significant negative loading (P22), however, since in the Cambridge study P22 has positively loaded on Factor A, the actual number of attitudes is equal to the mathematical number of factors (NF=4). It is interesting that although Factor A, represents the opinion of seven participants (pure loadings), its eigenvalue is greater than the eigenvalue of Factor C which involves the viewpoints of 10 participants. This issue is related to the very high loading coefficients (LC) of participants in Factor A. This factor represents the viewpoints of three participants which have LC>0.70. But the maximum value among all 10 LC in Factor C is 0.579 (P24). This is also correct when comparing the EVs of Factor B and Factor C. In Factor B, there are three LC>0.70. This is the reason why Factor B, with 6 significantly loaded participants, has a greater EV than that of Factor C with 10 representatives. Factor D, with the smallest EV among four extracted factors, represents the view of two participants. Final scores for each factor have been shown in Table 5-8. The following subsections describe each of these four attitudes and the areas which have been emphasised by these factors.

Table 5-8: Factor scores for Cambridge

No	Statement	A	B	C	D
1	Roles and responsibilities for climate change adaptation are not clear across levels of government	1	2	-1	-3
2	Roles and responsibilities for climate change adaptation are not clear between the public and private sector.	0	1	2	3
3	An effective leadership on climate change policy is lacking at the national level.	2	2	1	-3
4	An effective leadership on climate change policy is lacking at the local level.	-1	1	0	1
5	There is a lack of coordination between climate change and transport departments at the national/regional level.	1	0	1	-1
6	There is a lack of coordination between climate change and transport departments at the local level.	-2	-3	2	0
7	Current transport governance arrangements are unsatisfactory for delivery of climate change adaptation policies and strategies	0	0	-2	2
8	Devolving transport power from national/regional level to local level accelerates the climate change adaptation process.	0	-2	0	3
9	There is a disconnection between the current national funding mechanism and sustainable transport policy objectives.	3	-2	1	0
10	Local transport authorities have adequate resources to recruit required climate change experts.	-2	-2	-3	0
11	Local transport authorities have adequate expert staff to deal with the impacts of climate change on the road transport system.	-1	-1	-3	2

No	Statement	A	B	C	D
12	Government should give higher priority to adapt road users and existing transport infrastructures to the climate change rather than construction of new infrastructure.	-1	0	-1	2
13	Transport-related decisions are made by the authority with implementation power rather than reaching a consensus jointly with other stakeholders on conflicting issues.	2	-3	1	1
14	There are not enough guidelines for integrating climate change policies into the larger sustainable urban transport framework.	2	3	-1	-2
15	There are not enough guidelines for transport decision makers to deal with an uncertain climate future.	-3	+2	-2	0
16	Financial benefits of the climate change adaptation cannot persuade politicians to implement the climate change adaptation policies.	-1	3	1	-3
17	There is discretionary power for the local/regional level actors to prioritise the implementation of the transport projects.	2	0	2	0
18	The scepticism of politicians on the existence and importance of climate change are a significant barrier in the way of effective climate change adaptation.	3	-1	3	-1
19	Local/regional authorities should give higher priority to climate change on their agenda.	-1	-1	0	-2
20	A lack of political will and support has slowed down the process of climate change adaptation.	0	1	2	-2
21	Climate change adaptation policies are mostly incorporated into transport policies, but there is a gap between the policy directives and actual practices.	-3	-2	3	2
22	The top-down decision-making about the climate change adaptation is resulting in inconsistent policies and implementation failure at the local level.	1	0	-3	1
23	It is very difficult to reach a consensus among different transport organisations at different levels regarding transport issues.	2	-3	0	-1

No	Statement	A	B	C	D
24	Transport authorities' decisions are more consistent with the attitudes of their political parties, than addressing the actual needs of urban areas.	0	1	-1	-1
25	There is a clear need to improve the transparency in the decision making process for transport investment.	0	3	-2	-1
26	Current transport arrangements offer adequate participation for stakeholders, interest groups and academia in dealing with the uncertain impacts of climate change.	-2	1	0	1
27	Direct stakeholder participation is not beneficial, since the politicians themselves represent the opinions of stakeholders.	-2	-1	0	1
28	Adequate financial incentives are available for transport authorities to adapt the transport sector to climate change.	-1	0	-1	0
29	There is not sufficient public demand for climate change adaptation.	0	-1	0	0
30	The tension between short-term electoral cycle and long-term nature of climate change has reduced the political will.	1	0	3	1
31	The uncertain climate change risk assessment has challenged the process of decision making.	1	2	1	-2
32	For the purpose of evaluation and monitoring, there are adequate information and guidelines available about the climate change and adaptation measures at the local level.	-2	-1	-2	2
33	The existing financing mechanism permits decision makers to secure project approval and funding through under-estimating the long-term cost of the project.	1	2	2	-2
34	Current climate change adaptation activities in the transport sector are mostly proactive.	3	1	-1	-1
35	Devolution of transport powers, from the national/regional level to the local level, increases the degree of political influence on decisions.	-3	-2	-2	3

5.3.1 Factor A: Need for Detailed Guidance and Design Standards

This factor represents the opinions of nine participants and explains 17.44% of total variance of the study which is more than 33.6% of the remaining variance of the study after doing factor analysis. Seven participants were purely loaded on this factor and two participants were confounded between this attitude and factors C (P9) and D (P22). However, as explained above the loading coefficient for P22 on Factor D is negative confirming that this participant has also purely loaded on Factor A. An interesting ability of the Q-methodology appeared in this factor. As discussed in Chapter 3, one of the advantages of the Q methodology is to find the distinct viewpoints. As discussed below, this attitude clearly related the different types of barriers (institutional, political, economic and scientific) to transport and climate change governance at the national level.

The supporters of this attitude are of the common opinion that the existing progress of road transport sector is not enough to lead to a resilient transport system (S34). In addition, the existence of a gap between the policy directives and actual practice has highlighted that climate change adaptation policies are mostly incorporated into transport policies (S21). In other words, this attitude is optimistic about the progress that Cambridge's road transport sector has had with respect to climate change and its impacts.

The main themes which can be highlighted in this attitude are related to economic, political and institutional barriers. The gap between sustainable transport objectives and the existing funding mechanism for transport projects has received the maximum possible score of +3 in this attitude (S9). This issue can be confirmed in other statements as well. It has been agreed that the local transport authorities do not have adequate experts to deal with climate change issue (S11) and also do not have enough funds to recruit the required experts (S10). It was also agreed in this attitude that there are not financial incentives available for transport authorities regarding climate change adaptation (S28).

Political barriers are the second most important type of barriers perceived by the supporters of this attitude. The existence of skepticism among politicians about climate change and its impacts has been agreed strongly (+3) in this factor (S18). To a lesser extent, it was also agreed that the tension between the long-term nature of climate change and the short-term electoral cycle have hampered the progress on climate change adaptation (S30). The significant role of politicians in the prioritiation of transport investments (S26) and the lack of opportunity for different stakeholders to be involved in the decision making process were criticised by this attitude (S27). It was argued that transport-related decisions are mostly consistent with the attitudes of authorities which have the implementation power (S13, S23).

This attitude is neutral regarding the satisfactoriness of the existing transport governance arrangements in the implementation and delivery of climate change adaptation policies (S7). However, it highlights the need for an effective policy at the national level on climate change adaptation (S3). On the other hand, it does not recognise the lack of coordination between different local organisations to be significant (S6). Similarly, the need for improving the transparency in transport decision making process was not scored positive nor negative (S25).

A need for detailed guidance regarding the integration of climate change adaptation policies with transport policies (S14) and also the availability of guidelines for the purpose of monitoring the progress of climate change adaptation are highlighted among statements (S32). One interesting issue which can be concluded from the scores of this factor is that this attitude does not see the uncertainty of climate change impacts as the main reason for the need for detailed guidelines (S15, S31). However, it relates this requirement to the existence of the discretionary power of the local transport authorities in the implementation of national transport plans (S22). In other words, this attitude does not consider the scientific barriers of climate change significant. It has mostly emphasised on the institutional issues which will emerge in delivery of climate change adaptation policies without a detailed guideline.

(-3)	(-2)	(-1)	0	(+1)	(+2)	(+3)
There are not enough guidelines for transport decision makers to deal with an uncertain climate future.	There is a lack of coordination between climate change and transport departments at the local level.	An effective leadership on climate change policy is lacking at the local level.	Roles and responsibilities for climate change adaptation are not clear between the public and private sector.	Roles and responsibilities for climate change adaptation are not clear across levels of government	An effective leadership on climate change policy is lacking at the national level.	There is a disconnection between the current national funding mechanism and sustainable transport policy objectives.
Climate change adaptation policies are mostly incorporated into transport policies, but there is a gap between the policy directives and actual practices.	Local transport authorities have adequate resources to recruit required climate change experts.	Local transport authorities have adequate expert staff to deal with the impacts of climate change on the road transport system.	Current transport governance arrangements are unsatisfactory for delivery of climate change adaptation policies and strategies	There is a lack of coordination between climate change and transport departments at the national/regional level.	Transport-related decisions are made by the authority with implementation power rather than reaching a consensus jointly with other stakeholders on conflicting issues.	The scepticism of politicians on the existence and importance of climate change are a significant barrier in the way of effective climate change adaptation.
Devolution of transport powers, from the national/regional level to the local level, increases the degree of political influence on decisions.	Current transport arrangements offer adequate participation for stakeholders, interest groups and academia in dealing with the uncertain impacts of climate change.	Government should give higher priority to adapt road users and existing transport infrastructures to the climate change rather than construction of new infrastructure.	Devolving transport power from national/regional level to local level accelerates the climate change adaptation process.	The top-down decision-making about the climate change adaptation is resulting in inconsistent policies and implementation failure at the local level.	There are not enough guidelines for integrating climate change policies into the larger sustainable urban transport framework.	Current climate change adaptation activities in the transport sector are mostly proactive.
	Direct stakeholder participation is not beneficial, since the politicians themselves represent the opinions of stakeholders.	Short term financial benefits of the climate change adaptation cannot persuade politicians to implement the climate change adaptation policies.	A lack of political will and support has slowed down the process of climate change adaptation.	The tension between short-term electoral cycle and long-term nature of climate change has reduced the political will.	There is discretionary power for the local/regional level actors to prioritise the implementation of the transport projects.	
	For the purpose of evaluation and monitoring, there are adequate information and guidelines available about the climate change and adaptation measures at the local level.	Local/regional authorities should give higher priority to climate change on their agenda.	Transport authorities' decisions are more consistent with the attitudes of their political parties, than addressing the actual needs of urban areas.	The uncertain climate change risk assessment has challenged the process of decision making.	It is very difficult to reach a consensus among different transport organisations at different levels regarding transport issues.	
		Adequate financial incentives are available for transport authorities to adapt the transport sector to climate change.	There is a clear need to improve the transparency in the decision making process for transport investment.	The existing financing mechanism permits decision makers to secure project approval and funding through under-estimating the long-term cost of the project.		
			There is not sufficient public demand for climate change adaptation.			

Figure 5-7: Average Q Sort for factor A, Cambridge

5.3.2 Factor B: Lack of Leadership and Clear Distribution of Roles

Factor B, with an eigenvalue of 3.72, represents the opinions of six participants. All these six participants have purely loaded on this factor without confoundedness. This factor involves 13.77% of the total variance of the study which is about 27% of the remaining variance after the Q-factor analysis and Varimax rotation functions were performed. Another interesting ability of the Q-methodology has been occurred in this factor. As shown in Table 5-8, there are more than 20 statements in Factor B which have obtained a similar score as they have obtained in Factor A. However, Q-methodology has extracted this factor as a distinct factor given that the differences between other statements are big enough to introduce a new attitude. Since Factor A was described in section 5.3.1, this section explains the similarities between the two factors and discusses the emphasised areas in Factor B.

Similar to Factor A, Factor B has put a large emphasis on available funds for transport authorities. However, unlike Factor A, this attitude recognises the scientific group of barriers including lack of guidelines to be the second most important set of barriers. This attitude accepts that the local transport authorities do not have adequate climate change experts (S11) and also do not have enough funds to recruit the required experts (S10). However, unlike Factor A, this attitude has more emphasis on the role of climate change uncertainty in recognizing the need for required experts.

Among four extracted factors, Factor B has given the highest score (+2) to the negative role of climate change uncertainty in challenging the decision making process (S31). Similarly, this factor has given the largest possible score (+3) to statement S14 confirming the need for the local authorities to be provided with detailed guidelines in integrating climate change adaptation policies into sustainable transport frameworks. In addition, Factor B is the only factor that has given a positive score (+2) to the need for detailed guidelines for transport decision makers in dealing with an uncertain climate change future (S15). Moreover, the role of uncertainty of climate change impacts and consequently the lack of short-term financial benefits of climate change for politicians have obtained a score of '+3' and '+2' in statements S16 and S33, respectively. Unlike Factor A which emphasized on the lack of connections between sustainable transport objectives and the national funding mechanism, this attitude criticises the lack of transparency about transport decisions at the local level (S25).

Although this factor is neutral regarding statement S7 which is the satisfactoriness of the existing transport governance arrangements in the delivery of climate change adaptation policies but it has more emphasis on centralised approach than that Factor A does. Although this attitude rejects the role of devolution of more powers from the national level to the local level in increasing the political influence on transport decisions (S35) but Factor B is the only factor which has disagreed with decentralised approach in the efficient delivery of climate change adaptation policies (S8). However, it should be emphasised that using the scores of this factor it is not possible to make a robust conclusion about the acceptance of a top-down or bottom-up approach (S22).

This factor does not consider the politicians' skepticism as a barrier for climate change adaptation process at the local level (S18). This has been confirmed with Statement S19 where this factor is the only factor which does not oppose the existing level of the public demand for climate change adaptation (S29). In addition, this attitude is the only one, among the four, which has not assigned a positive score to statement S30, hence it does not recognise the short-term electoral cycles as a barrier for the long-term vision of politicians in transport-related decisions.

Unlike all other factors, this attitude strongly disagrees with the lack of adequate opportunity for stakeholders to involve themselves in the transport decision-making process. Statement S13 with a score of '-3' shows that this attitude agrees that transport decisions are made jointly with other stakeholders. Similarly, statement S23 with a score of '-3' confirms that this attitude supports the easiness of reaching a consensus among different stakeholders at different levels. In addition, (S6) has strongly disagreed with the lack of coordination between authorities at the local level. However, the lack of leadership at the national level (S3) and unclear distribution of roles and responsibilities for climate change adaptation (S1) were perceived as significant in this attitude.

(-3)	(-2)	(-1)	0	(+1)	(+2)	(+3)
There is a lack of coordination between climate change and transport departments at the local level.	Devolving transport power from national/regional level to local level accelerates the climate change adaptation process.	Local transport authorities have adequate expert staff to deal with the impacts of climate change on the road transport system.	There is a lack of coordination between climate change and transport departments at the national/regional level.	Roles and responsibilities for climate change adaptation are not clear between the public and private sector.	Roles and responsibilities for climate change adaptation are not clear across levels of government	There are not enough guidelines for integrating climate change policies into the larger sustainable urban transport framework.
Transport-related decisions are made by the authority with implementation power rather than reaching a consensus jointly with other stakeholders on conflicting issues.	There is a disconnection between the current national funding mechanism and sustainable transport policy objectives.	The scepticism of politicians on the existence and importance of climate change are a significant barrier in the way of effective climate change adaptation.	Current transport governance arrangements are unsatisfactory for delivery of climate change adaptation policies and strategies	An effective leadership on climate change policy is lacking at the local level.	An effective leadership on climate change policy is lacking at the national level.	Financial benefits of the climate change adaptation cannot persuade politicians to implement the climate change adaptation policies.
It is very difficult to reach a consensus among different transport organisations at different levels regarding transport issues.	Local transport authorities have adequate resources to recruit required climate change experts.	Local/regional authorities should give higher priority to climate change on their agenda.	Government should give higher priority to adapt road users and existing transport infrastructures to the climate change rather than construction of new infrastructure.	A lack of political will and support has slowed down the process of climate change adaptation.	There are not enough guidelines for transport decision makers to deal with an uncertain climate future.	There is a clear need to improve the transparency in the decision making process for transport investment.
	Climate change adaptation policies are mostly incorporated into transport policies, but there is a gap between the policy directives and actual practices.	Direct stakeholder participation is not beneficial, since the politicians themselves represent the opinions of stakeholders.	There is discretionary power for the local/regional level actors to prioritise the implementation of the transport projects.	Transport authorities' decisions are more consistent with the attitudes of their political parties, than addressing the actual needs of urban areas.	The uncertain climate change risk assessment has challenged the process of decision making.	
	Devolution of transport powers, from the national/regional level to the local level, increases the degree of political influence on decisions.	There is not sufficient public demand for climate change adaptation.	The top-down decision-making about the climate change adaptation is resulting in inconsistent policies and implementation failure at the local level.	Current transport arrangements offer adequate participation for stakeholders, interest groups and academia in dealing with the uncertain impacts of climate change.	The existing financing mechanism permits decision makers to secure project approval and funding through under-estimating the long-term cost of the project.	
		For the purpose of evaluation and monitoring, there are adequate information and guidelines available about the climate change and adaptation measures at the local level.	Adequate financial incentives are available for transport authorities to adapt the transport sector to climate change.	Current climate change adaptation activities in the transport sector are mostly proactive.		
			The tension between short-term electoral cycle and long-term nature of climate change has reduced the political will.			

Figure 5-8: Average Q Sort for factor B, Cambridge

5.3.3 Factor C: Need for a Better Coordination Between Stakeholders

This attitude explains 13.22% of the total variance of the study in Cambridge which is more than 25% of the remaining variance. Although this factor has smaller eigenvalue than those of factors A and B but 10 participants are significantly loaded on this factor which is more than 37% of the sample size. One of these 10 participants is confounded between this factor and Factor A.

Analysis of the scores for this factor shows that the economic factors are considered as the most important factors influencing the process of climate change adaptation in road transport sector. This involves both the availability of financial resources (S10, S11) and the issues related to funding mechanism (S33). Statement S28 shows that, according to this attitude there is not sufficient funds to implement the adaptation measures in road transport sector and close the gap between policy directives and actual practices (S21). In addition, it has been strongly agreed that transport authorities do not have adequate resources to recruit required climate change experts (S10, S11). Although this attitude has considered political barriers to be significant but the scores show that economic factors play a significant role in increasing or decreasing political will and support. From Factor C's point of view, politicians' willingness and support for climate change adaptation is reduced when there is a need for cost-benefit analysis for the implementation of climate change adaptation measures (S16).

Factor C has more emphasis on political factors than those other factors do. This factor gives a score of '+2' to statement 20 and a score of '+3' to statement S18 claiming that politicians are still skeptical about the importance and even existence of climate change which impedes the effective progress towards a climate change resilient transport system. Statement 30 clarifies the main reason for the lack of political will. This attitude is the only attitude which has given a score of '+3' to statement 30 asserting that short-term political cycles are not matched with the long-term nature of climate change which consequently reduces politicians willingness for supporting climate change adaptation.

An interesting finding from this factor is that although political factors have received a high level of attention from the supporters of this factor (scores for S30 and S18 are +3) but they have not considered those political issues to be influencing factors in practice. Findings show that this attitude supports the appropriateness of the existing transport governance arrangements in Cambridge (S7, S22). In addition, this attitude gives a score of '-2' to statement S35 and a score of '+2' to statement S17 which supports decentrilised governance arrangements. To summarise, Factor C sees politicians as stakeholders who do not support climate change but since the local authorities have adequate power regarding climate change and transport matters, politicians' reluctance cannot be effective in practice (S24).

Scientific barriers were not perceived to be a significant set of barriers in the process of climate change adaptation. This was not surprising since as discussed in previous sections there is usually a positive correlation between political and scientific barriers; however, in this attitude political factors were not considered significant, and scientific issues also are not highlighted by this factor's supporters. Instead of focusing on uncertainty about climate change and its impacts and their overall influence on political will and support, this attitude have emphasized on the lack of guidance in integrating climate change adaptation policies within sustainable transport policies (S14) and monitoring the progress of climate change adaptation at the local level (S32).

The decision making process of transport matters are considered to be transparent (S25) in this attitude. However, this attitude is completely silent regarding the issue of participation of different stakeholders in transport decision making process by giving a score of '0' to statements S26, S27 and S23. Within the group of institutional barriers, a better coordination between climate change and transport departments at the national level and the clarification of responsibilities of public and private organisations at the local level can be considered as the main recommendations of the supporters of Factor C.

(-3)	(-2)	(-1)	0	(+1)	(+2)	(+3)
Local transport authorities have adequate resources to recruit required climate change experts.	Current transport governance arrangements are unsatisfactory for delivery of climate change adaptation policies and strategies	Roles and responsibilities for climate change adaptation are not clear across levels of government	An effective leadership on climate change policy is lacking at the local level.	An effective leadership on climate change policy is lacking at the national level.	Roles and responsibilities for climate change adaptation are not clear between the public and private sector.	The scepticism of politicians on the existence and importance of climate change are a significant barrier in the way of effective climate change adaptation.
Local transport authorities have adequate expert staff to deal with the impacts of climate change on the road transport system.	There are not enough guidelines for transport decision makers to deal with an uncertain climate future.	Government should give higher priority to adapt road users and existing transport infrastructures to the climate change rather than construction of new infrastructure.	Devolving transport power from national/regional level to local level accelerates the climate change adaptation process.	There is a lack of coordination between climate change and transport departments at the national/regional level.	There is a lack of coordination between climate change and transport departments at the local level.	Climate change adaptation policies are mostly incorporated into transport policies, but there is a gap between the policy directives and actual practices.
The top-down decision-making about the climate change adaptation is resulting in inconsistent policies and implementation failure at the local level.	There is a clear need to improve the transparency in the decision making process for transport investment.	There are not enough guidelines for integrating climate change policies into the larger sustainable urban transport framework.	Local/regional authorities should give higher priority to climate change on their agenda.	There is a disconnection between the current national funding mechanism and sustainable transport policy objectives.	There is discretionary power for the local/regional level actors to prioritise the implementation of the transport projects.	The tension between short-term electoral cycle and long-term nature of climate change has reduced the political will.
	For the purpose of evaluation and monitoring, there are adequate information and guidelines available about the climate change and adaptation measures at the local level.	Transport authorities' decisions are more consistent with the attitudes of their political parties, than addressing the actual needs of urban areas.	It is very difficult to reach a consensus among different transport organisations at different levels regarding transport issues.	Transport-related decisions are made by the authority with implementation power rather than reaching a consensus jointly with other stakeholders on conflicting issues.	A lack of political will and support has slowed down the process of climate change adaptation.	
	Devolution of transport powers, from the national/regional level to the local level, increases the degree of political influence on decisions.	Adequate financial incentives are available for transport authorities to adapt the transport sector to climate change.	Current transport arrangements offer adequate participation for stakeholders, interest groups and academia in dealing with the uncertain impacts of climate change.	Financial benefits of the climate change adaptation cannot persuade politicians to implement the climate change adaptation policies.	The existing financing mechanism permits decision makers to secure project approval and funding through under-estimating the long-term cost of the project.	
		Current climate change adaptation activities in the transport sector are mostly proactive.	Direct stakeholder participation is not beneficial, since the politicians themselves represent the opinions of stakeholders.	The uncertain climate change risk assessment has challenged the process of decision making.		
			There is not sufficient public demand for climate change adaptation.			

Figure 5-9: Average Q Sort for factor C, Cambridge

5.3.4 Factor D: Need for Inclusion of the Private Sector

Factor D represents the viewpoint of two participants and explains 7.46% of total variance of the study in Cambridge. Three participants were significantly loaded on this factor but P22 is confounded between Factor A and Factor D with loading coefficients of 0.462 and -0.711, respectively. Hence, P22 is considered as an exemplifier for Factor A, and Factor D has only two representatives, P14 and P20.

Unlike three other factors, Factor D does not see the uncertainty about climate change as a barrier in decision making process (S31). Along the same lines, political barriers were not highlighted by the supporters of this factor (S16, S18, S20, S24) although it does not deny the role of short term electoral cycle in addressing the long term impacts of climate change (S30). Moreover, it has been argued that there are adequate guidelines for transport decision makers at different levels to integrate transport policies with larger sustainable development programs (S14, S15, S32).

This attitude is the only attitude which finds the existing transport governance arrangements unsatisfactory in the delivery of climate change adaptation strategies (S7). In addition, unlike other factors, Factor D considers the decentralisation of transport responsibilities as an influential factor in the implementation of climate change policies (S8); however, it raises a concern about increasing political influence through decentralisation (S35). Similarly, S22 shows that this attitude considers the current top-down decision making about climate change adaptation as a barrier for implementation failure at the local level. Moreover, Factor D is the only attitude which does not consider the lack of resources and experts at the local level to be critical (S9, S10, S11) although there are not adequate financial incentives available to adapt the transport sector to climate change (S28).

To summerise, Factor D is positive regarding the existing governance arrangements in addressing the uncertainty, awareness raising, funding mechanism, participation of different stakeholders. However, it asks for more business cases for the inclusion of private sector through clear distribution of roles and responsibilities in dealing with climate change adaptation issue.

(-3)	(-2)	(-1)	0	(+1)	(+2)	(+3)
Roles and responsibilities for climate change adaptation are not clear across levels of government	There are not enough guidelines for integrating climate change policies into the larger sustainable urban transport framework.	There is a lack of coordination between climate change and transport departments at the national/regional level.	There is a lack of coordination between climate change and transport departments at the local level.	An effective leadership on climate change policy is lacking at the local level.	Current transport governance arrangements are unsatisfactory for delivery of climate change adaptation policies and strategies	Roles and responsibilities for climate change adaptation are not clear between the public and private sector.
An effective leadership on climate change policy is lacking at the national level.	Local/regional authorities should give higher priority to climate change on their agenda.	The scepticism of politicians on the existence and importance of climate change are a significant barrier in the way of effective climate change adaptation.	There is a disconnection between the current national funding mechanism and sustainable transport policy objectives.	Transport-related decisions are made by the authority with implementation power rather than reaching a consensus jointly with other stakeholders on conflicting issues.	Local transport authorities have adequate expert staff to deal with the impacts of climate change on the road transport system.	Devolving transport power from national/regional level to local level accelerates the climate change adaptation process.
Financial benefits of the climate change adaptation cannot persuade politicians to implement the climate change adaptation policies.	A lack of political will and support has slowed down the process of climate change adaptation.	It is very difficult to reach a consensus among different transport organisations at different levels regarding transport issues.	Local transport authorities have adequate resources to recruit required climate change experts.	The top-down decision-making about the climate change adaptation is resulting in inconsistent policies and implementation failure at the local level.	Government should give higher priority to adapt road users and existing transport infrastructures to the climate change rather than construction of new infrastructure.	Devolution of transport powers, from the national/regional level to the local level, increases the degree of political influence on decisions.
	The uncertain climate change risk assessment has challenged the process of decision making.	Transport authorities' decisions are more consistent with the attitudes of their political parties, than addressing the actual needs of urban areas.	There are not enough guidelines for transport decision makers to deal with an uncertain climate future.	Current transport arrangements offer adequate participation for stakeholders, interest groups and academia in dealing with the uncertain impacts of climate change.	Climate change adaptation policies are mostly incorporated into transport policies, but there is a gap between the policy directives and actual practices.	
	The existing financing mechanism permits decision makers to secure project approval and funding through under-estimating the long-term cost of the project.	There is a clear need to improve the transparency in the decision making process for transport investment.	There is discretionary power for the local/regional level actors to prioritise the implementation of the transport projects.	Direct stakeholder participation is not beneficial, since the politicians themselves represent the opinions of stakeholders.	For the purpose of evaluation and monitoring, there are adequate information and guidelines available about the climate change and adaptation measures at the local level.	
		Current climate change adaptation activities in the transport sector are mostly proactive.	Adequate financial incentives are available for transport authorities to adapt the transport sector to climate change.	The tension between short-term electoral cycle and long-term nature of climate change has reduced the political will.		
			There is not sufficient public demand for climate change adaptation.			

Figure 5-10: Average Q Sort for factor D, Cambridge

5.4 Conclusion

Findings in this chapter show that transport stakeholders in Belfast and Cambridge have experienced different kinds of barriers in the implementation and delivery of climate change adaptation policies at the local level. Participants in Belfast with a centralised transport governance arrangements, raised their concerns mainly regarding the initiation of climate change adaptation policies; whereas participants in Cambridge with a decentralised transport governance arrangements, put more emphasises on the barriers perceived during actual implementation and the delivery of climate change policies.

According to the results from Q factor analysis, there are four main attitudes among Belfast's participants. Firstly, there is not enough political will for climate change. Uncertainty about climate change and short term electoral cycle and its conflict with the long term impacts of climate change were considered as the main barriers in improving the political support for climate change adaptation. Secondly, a lack of expertise at the local level, mainly as a result of financial constraints, is perceived to be an influential barrier in the integration of climate change adaptation policies with transport policies. Thirdly, it is argued that the existing emphasis of transport decision makers in the construction of new roads has missed the opportunity for adapting the existing road to the future impacts of climate change. Finally, increasing the public awareness is suggested to be an effective approach in increasing the public demand for climate change adaptation and the improvement of political support.

The analysis of Q methodology in Cambridge shows that Cambridge has passed the initiation step of policy cycle. Participants in this case study shared their concerns mostly about the actual barriers for the implementation of climate change adaptation policies within the road transport sector. The lack of guidelines and design standards received the highest attention from the study participants. It can be concluded that since the implementation of climate change adaptation policies has been included in transport decision making process, different stakeholders have found gaps in the policy documents. Lack of leadership and clear distribution of roles and responsibilities across different levels of the government are considered as the second important barrier. This is followed by a need for a better coordination between different stakeholders at different levels of transport governance structure most importantly between the Cambridge City Council and the Cambridgeshire County Council. Finally, the inclusion of private sector in the process of adapting transport sector to climate change impacts through introducing business cases for climate change adaptations is suggested to be an effective approach in the delivery of sustainable transport policies at the local level.

The findings of this chapter shows that Q methodology offers a strong tool for policy analysts to investigate the different belief systems surrounding the topic under investigation. As discussed in Chapter 2 and was proved in the findings of this chapter, even when two participants are from a same organisation, their viewpoints is not necessarily in accordance with each other.

Findings from this chapter reveals that Q methodology is also a strong approach for conducting a comparative case study research. Table 5-9 shows the rank of statements in Belfast and Cambridge. It should be noted that these ranked are calculated considering the weight of factors (eigenvalues). As discussed in section 3.4, two case studies in this research were mainly selected based on differences in their existing transport governance arrangements. The correlation of 0.22 between two ranks illustrates that Q was able to reveal the role of power distribution models in effectiveness of the transport governance arrangements in delivery of climate change adaptation policies.

Q methodology is a powerful approach to reveal differences in viewpoints as it systematically analyses opinions and extracts attitudes. The only role of the researcher is interpreting these extracted factors (attitudes) which provides minimum flexibility for the researcher in introducing bias into the research findings. The findings of this chapter are contrasted with the finding of interviews in Chapter 6.

Table 5-9: Rank of statements in Belfast and Cambridge (out of 36)

Statement	Belfast	Cambridge
Roles and responsibilities for climate change adaptation are not clear across levels of government	10	15
Roles and responsibilities for climate change adaptation are not clear between the public and private sector.	18	3
An effective leadership on climate change policy is lacking at the national level.	1	6
An effective leadership on climate change policy is lacking at the local level.	25	17
There is a lack of coordination between climate change and transport departments at the national/regional level.	4	12
There is a lack of coordination between climate change and transport departments at the local level.	22	30
Current transport governance arrangements are unsatisfactory for delivery of climate change adaptation policies and strategies.	17	20
Devolving transport power from national/regional level to local level accelerates the climate change adaptation process.	28	18
There is a disconnection between the current national funding mechanism and sustainable transport policy objectives.	7	10
Local transport authorities have adequate resources to recruit required climate change experts.	21	35
Local transport authorities have adequate expert staff to deal with the impacts of climate change on the road transport system.	24	32
Government should give higher priority to adapt road users and existing transport infrastructures to the climate change rather than construction of new infrastructure.	2	25
Transport-related decisions are made by the authority with implementation power rather than reaching a consensus jointly with other stakeholders on conflicting issues.	13	14
There are not enough guidelines for integrating climate change policies into the larger sustainable urban transport framework.	9	7
There are not enough guidelines for transport decision makers to deal with an uncertain climate future.	8	31

Financial benefits of the climate change adaptation cannot persuade politicians to implement the climate change adaptation policies.	6	13
There is discretionary power for the local/regional level actors to prioritise the implementation of the transport projects.	12	4
The scepticism of politicians on the existence and importance of climate change are a significant barrier in the way of effective climate change adaptation.	23	1
Local/regional authorities should give higher priority to climate change on their agenda.	26	29
A lack of political will and support has slowed down the process of climate change adaptation.	5	11
Climate change adaptation policies are mostly incorporated into transport policies, but there is a gap between the policy directives and actual practices.	19	26
The top-down decision-making about the climate change adaptation is resulting in inconsistent policies and implementation failure at the local level.	14	24
It is very difficult to reach a consensus among different transport organisations at different levels regarding transport issues.	20	23
Transport authorities' decisions are more consistent with the attitudes of their political parties, than addressing the actual needs of urban areas.	11	19
There is a clear need to improve the transparency in the decision making process for transport investment.	30	16
Current transport arrangements offer adequate participation for stakeholders, interest groups and academia in dealing with the uncertain impacts of climate change.	16	21
Direct stakeholder participation is not beneficial, since the politicians themselves represent the opinions of stakeholders.	32	28
Adequate financial incentives are available for transport authorities to adapt the transport sector to climate change.	27	27
There is not sufficient public demand for climate change adaptation.	3	22
The tension between short-term electoral cycle and long-term nature of climate change has reduced the political will.	29	2
The uncertain climate change risk assessment has challenged the process of decision making.	34	9
For the purpose of evaluation and monitoring, there are adequate information and guidelines available about the climate change and adaptation measures at the local level.	35	33

The existing financing mechanism permits decision makers to secure project approval and funding through under-estimating the long-term cost of the project.	15	5
Current climate change adaptation activities in the transport sector are mostly proactive.	33	8
Devolution of transport powers, from the national/regional level to the local level, increases the degree of political influence on decisions.	31	34

Chapter 6 - Conclusions, Recommendations, Contribution to Knowledge and Future Research

6.1 Introduction

The aim of this research was to assess the relationship between transport governance arrangements and the effective delivery of climate change adaptation polices at the local level. This chapter summarises the findings from this research project and proposes recommendations to improve the progress of the implementation of climate change adaptation policies. This chapter has been divided into four sections. Section 6.2 which presents the findings from Chapter 2 to Chapter 5, is divided into four sub-sections. Section 6.2.1 includes the main findings of the literature review. These findings have influenced the designing of empirical research including the methodology presented in Chapter 3. Section 6.2.2 contains the justifications for the research design and suggestions which can improve the reliability of the Q methodology when conducting a policy analysis research. Sections 6.2.3 and 6.2.4 discuss the main findings of the empirical phase of the research in Belfast and Cambridge, respectively. This chapter is then followed by Section 6.3 to fulfill the sixth objective of this research by providing recommendations to improve the integration of climate change adaptation policies into urban road transport governance. Section 6.4 summarises the contribution of this research to the existing knowledge not only from the policy implementation perspective but also from the methodological point of view. And finally, Section 6.5 proposes new areas which can be researched in the future. This section presents these areas in separate sub-sections to cover interested policy analysts, Q methodologist and sustainable transport researchers.

6.2 Conclusions

6.2.1 Literature Review

Findings show that the implementation of climate change adaptation policies in transport sector is a complex process not only because of the uncertain impacts of climate change which hamper rational decision making process but also due to the existence of a variety of interests of stakeholders at different levels of transport governance which is a significant barrier for an efficient and effective decision making process. The literature review shows that these barriers can be categorized in five themes.

The first theme involves scientific factors including the uncertainty about climate change impacts and the availability of scientific information and guidelines for decision makers. In most climate change studies although this group of barriers have been considered in the research design but there are not enough investigations which emphasise on the impact of uncertain climatic conditions on effective and efficient decision making.

The second group of barriers involves institutional factors. According to empirical studies, a lack of coordination and collaboration between different stakeholders at different levels was perceived to be a significant barrier in the implementation of climate change adaptation policies. Effective coordination between different sectors is recognised as equally important as effective intra-organisational working relationships. It has been highlighted that, given the multi-dimensional aspects of climate change, a good working relationships between stakeholders at different levels is a mandatory requirement for effective climate change policy development and implementation. This issue is an important factor in transport sector. In addition to the existence of a variety of stakeholders at different levels (e.g. local, regional and national governments), the issue of better horizontal coordination among stakeholders is a significant factor when considering the integration of climate change adaptation policies within transport sector. This is because any transport decision in a specific local/regional area can have an important impact on other local areas.

A negative impact of unclear distribution of roles and responsibilities between the local and national governments on effective policy implementation is highlighted in the literature where this issue is linked to the lack of political will at the national level. It has been argued that due to an ambiguity in the distribution of roles and responsibilities, climate change adaptation is not considered a high priority for local level stakeholders since their feeling is that climate change is not a top priority for the national government.

Another significant factor within the institutional set of barriers is related to the power distribution model. Although there are conflicting opinions regarding the appropriateness of top-down or bottom-up approaches in the delivery of climate change adaptation decisions but the dominant view is that the national government should give more power to local level actors in both formulating and implementing climate change adaptation policies. Given that climate change impacts vary at different local areas, it is argued that the top-down decision making cannot be effective. This is because local stakeholders including local governments have more experience on the actual impacts of climate change in their regions they can design better plans. It is also highlighted that local actors have more motivation to implement those climate change policies that they were involved in their decision making process.

Political factors can be categorised as the third theme of barriers. Although a lack of public demand for climate change adaptation was considered as an important factor but the literature recognises political will as the most significant barrier in this category. It is argued that politicians play a significant role in shaping the public attitude towards the existence and importance of climate change. It can be concluded that a lack of political will towards climate change and adaptation can create a vicious circle in which the public will not demand climate change adaptation as a result climate change will not be a high priority for the government. Moreover, the literature review shows that politicians usually focus on issues that have a shorter return upon investment which is not the case for climate change adaptation; since the benefit of climate change adaptation activities will emerge after more than a decade. This reminds the need for developing an innovative monitoring framework which can enable the stakeholders to track the progress over a shorter time scale. Combined with a list of clear and tangible short-term objectives, and improved awareness raising activities, this approach can inform the public about the progress over a given time scale, for example a specific political cycle. This in turn can increase the public demand for climate change adaptation.

Economic factors form the fourth category of barriers for climate change adaptation. Although the common opinion in the literature is that adapting road transport infrastructures to future climatic conditions requires no more than 10% of the total cost of the construction but the existence of a wide range of uncertainty about climate change impacts and the lack of public demand and political support will not persuade transport decision makers to pay enough attention to climate change adaptation issues due to financial pressures. Hence, it is not surprising that the budgeting mechanism of climate change adaptation activities has received more criticism than that of the availability of financial resource. The recent literature published in the context of climate change adaptation in transport sector shows that almost none of the European countries have a clear mechanism for financing climate change adaptation activities. With an unclear financing mechanism, fiscal austerity can cause other indirect impacts on the process of climate change adaptation such as shutting down climate change office/departments and cancelation of new staff positions.

The fifth group of barriers involves social and behavioural factors. Given the lack of public demand for climate change adaptation and the existence of financial constraints, the literature on climate change suggests that a proactive approach for climate change adaptation is a mandatory requirement. Different stakeholders perceive the impact of climate change differently. As a result, without a sustainable framework for the adaptation, climate change activities will tackle the perceived impacts which is a reactive approach.

The above mentioned category of barriers lists only some of the important factors which hamper the implementation of climate change adaptation policies (for more detail see chapter 2). It is clear from this discussion that the process of climate change adaptation involves many inter-correlated factors. For an example, the lack of public demand decreases political will, and the lack of political support reduces the budget for climate change activities and this in turn can reduce the public demand by limiting opportunities available for awareness raising activities. Due to multi-level cycles in climate change policy cycle, it can be concluded that a top-down decision making process cannot be an effective approach for the implementation and delivery of climate change adaptation objectives. On the other hand, bottom-up decision making also cannot be an effective approach for the integration of climate change adaptation policies within sustainable transport policies. As discussed in this chapter, the impact of a transport decision made for a specific local area does not respect the geographical boundaries of that area. Thus similar to the top-down approach, a bottom-up approach which emphasises the devolution of power and responsibilities from the national to the local level cannot be an effective approach.

The outcome of long-standing debates between the followers of top-down and bottom-up approaches is a mixed method approach combining elements of these two approaches. The conceptual framework of governance combines top-down and bottom-up approaches by considering the advantages of each. In practice, this framework is not much different from a combined top-down approach. However, it uses a different perspective to describe the policy implementation process. For example, as a softer form of governing (and instead of focusing on the availability of financial resource for policy implementers) it puts a significant emphasis on the transparency in decision making process. Or instead of focusing on effective cause and effect relationships, it highlights the role of effective working relationships between different stakeholders involved in the policy cycle. In this research project it was decided to use the good governance as a conceptual framework, and the designed methodology is based on this framework. In other words, this research has not limited itself to the factors which are significant from top-down or bottom-up perspectives; this is to avoid the researcher bias in designing and performing the empirical phase of the research. The main findings related to the methodological framework of this research have been reported in the following section.

6.2.2 Methodology

Review of literature on climate change policy analysis and sustainable transport governance shows that qualitative methods (interview, focus group and document analysis), have been the main method of data collection and data analysis in policy research. As discussed in chapter 3, although qualitative methods are helpful for collecting rich information about specific topics, due to the nature of unstructured data, there is not a robust data analysis method to enable policy analysts to investigate the relationships between different factors which are influencing the outcome of a policy. As a result, recommendations are not based on an accurate trade-offs between underlying factors which affect the policy implementation process.

As discussed in Chapter 1, this research aims to examine the effectiveness of transport governance arrangements in translating national climate change adaptation policies into the local initiatives and actions. This study employed the Q-methodology which is a mixed method approach combining the advantages of both qualitative and quantitative approaches. Q collects the required data qualitatively and analyses them quantitatively. Although the Q methodology has been used extensively in health science, there are only a few studies that have employed it to study the process of policy implementation. The first phase of the empirical research involving interviews with different stakeholders in two case study areas i.e. Belfast and Cambridge assessed the different attitudes regarding barriers to the implementation of climate change adaptation policies. The data qualitative collected in two cities was analysed to construct a set of factors which were recognised important in the process of policy implementation. Finally, these statements were used as a Q sample to compare the participants view about the barriers for climate change adaptation in two case study areas.

6.2.3 Empirical Findings in Belfast Case Study

6.2.3.1 Qualitative Data: Interviews

The qualitative analysis of interviews conducted in Belfast shows that although extreme weather is a significant climate change impact perceived by road transport stakeholders, flooding is the main impact of climate change in Belfast city area. On the other hand, increasing the air temperature caused by the climate change was not strongly underlined by Belfast participants. Only one participant highlighted the negative impact of warm weather (high temperature) on the comfort of the public transport users. Participants placed a great emphasis on the effect of increased rainfall on road surfaces and the need for giving a higher priority to road maintenance.

Findings in Belfast case study area show that the implementation of climate change adaptation policies within the road transport sector is not effective enough. The main criticism is that the current adaptation activities are mostly reactive to recent climate change impacts rather than being proactive to the future projections of climate change. Although findings show that transport stakeholders in Belfast have not ignored climate change and its impact totally but participants shared their concerns about uneconomical approaches to address climate change and emphasised the positive role of a long-term transport planning framework in reaching a cost-effective approach for resolving climate change and transport matters.

An interesting finding from the interviews in Belfast is that although climate change mitigation and climate change adaptation have been studied separately in most climate change literature but there is a need to combine these two segments of climate change in the context of road transport sector. On the one hand, attention to the sustainable modes of transport such as walking, cycling and public transport can decrease the amount of greenhouse gases emitted from transport sector, on the other hand, investing on constructing new roads can increase impermeable surfaces area which consequently can increase the vulnerability to climate change impacts for road transport users. Moreover, most impacts of climate change will emerge after a decade or more. Hence it is necessary to develop a long-term integration planning approach considering both climate change mitigation and climate change adaptation.

Participants shared their concerns about the obstacles against the effective and efficient implementation of climate change adaptation policies. The remaining of this section discusses the main barriers underlined in the interviews. The findings provide a strong evidence that the lack of political will and existence of political conflicts between responsible departments are the most influential barriers against adapting road transport sector to climate change impacts. Although there were some contradictory opinions, the dominant view is that there is not enough political will and support from Department for the Environment regarding climate change matters. However, there is a high level of consensus among participants that a better coordination between Departments of the Environment and Department for the Regional Development is required to make a better progress in the implementation of climate change adaptation policies within the road transport sector. According to the discussions, the existing conflict has at least three types of origins. Firstly and most importantly, the existence of uncertainties around climate change and the projected impacts has provided a non-rational atmosphere with respect to decisions related to climate change. Secondly, there is not enough demand from the public for climate change activities. Thirdly, the majority of climate change adaptation activities are not consistent with the short-term electoral cycles of politicians. By considering these three justifications, it can be concluded that there is a great opportunity for politicians to ignore climate change at this stage and perhaps that is why the Climate Change Bill has not been agreed yet in Northern Ireland.

A lack of financial resources and inappropriate financing mechanisms are recognised as the second most important set of barriers to implement climate change adaptation policies into road transport sector in Belfast. However, the analysis of the interviews shows that having an appropriate funding regime can address the lack of required funding. It was argued that politicians have an influential role in prioritizing transport investments which consequently have a negative impact on long-term integrated approaches for sustainable transport. The strong role of politicians in funding transport projects was perceived as the main reason for the current focus of the transport authorities on the construction of new roads and the lack of attention in demanding a sustainable transport system. Similar to the socio-political factors discussed above uncertainty about climate change impacts was perceived as the main barrier for considering climate change adaptation measures during road design process. The lack of integrated approaches for considering climate change and sustainability in road design was underlined by one participant. The existing financing mechanism was criticised for considering only the percentage value of allocated funding for climate change rather than assessing the whole life cycle of road projects against the projected impacts of climate change.

The third theme discussed in Belfast interviews is related to the lack of or inappropriate design guidelines, specifications and standards. The emphasis of existing road design standards on the statistical data available from the last decades was perceived as a main barrier towards achieving long-term resiliency. In addition, ignoring contingencies in road design guidelines was perceived as an important barrier not only as a result of climate change uncertainty but also due to the existence of contingencies in every road project. Moreover, the lack of joined-up thinking between different parts across the departments was highlighted during the discussions. Lack of consistency between transport and climate change adaptation policies, or between transport and land use policies were frequently discussed by study participants.

Institutional barriers formed another group of barriers. This group involves a variety of factors including the power distribution model between different stakeholders, the transparency of decision making process, the accountability of politicians and transport decision makers and the participation of climate change experts in transport decision making process. Although there were different attitudes towards each of these factors (see chapter 4) but according to the discussions undertaken in this project it can be concluded that there are great opportunities to improve the transparency of decisions and accountability of decision makers with respect to climate change and transport issues. It was emphasised that the consultation process for transport projects are not effective in practice which hampers the integration of transport matters into other issues such as land-use or climate change. Again, it was underlined that due to the strong role of politicians in prioritising the transport investments, decision making processes are not clear, and similarly, due to the lack of an independent accountable body, it is difficult to challenge decision makers. On the other hand, findings show that the existing centralised model is considered to be more efficient in comparison to decentralised models. However, it was strongly underlined that transport and planning authorities need to improve their coordination and also need to have a better understanding about other department's concerns on shared matters through improving their expertise and skills.

6.2.3.2 Q-methodology Findings

Findings from the Q-methodology revealed four different attitudes held by transport and climate change stakeholders in Belfast about the barriers against the implementation of climate change adaptation policies within the road transport sector. These factors were discussed in detail in Chapter 5 and this section discusses the main consensus areas between four extracted viewpoints. There is a high level of consensus over seven statements as shown in Table 6-1. Four statements are agreed and three statements are disagreed across all attitudes.

Table 6-1: Consensus between four extracted factors, Belfast (all agreed/disagreed or neutral)

No	Statement	A	B	C	D
3	An effective leadership on climate change policy is lacking at the national level.	1	3	0	1
5	There is a lack of coordination between climate change and transport departments at the national/regional level.	0	0	3	2
12	Government should give higher priority to adapt road users and existing transport infrastructures to the climate change rather than construction of new infrastructure.	1	0	2	2
9	There is a disconnection between the current national funding mechanism and sustainable transport policy objectives.	0	2	0	1

27	Direct stakeholder participation is not beneficial, since the politicians themselves represent the opinions of stakeholders.	-1	-1	-1	-1
34	Current climate change adaptation activities in the transport sector are mostly proactive.	0	-3	-1	0
32	For the purpose of evaluation and monitoring, there are adequate information and guidelines available about the climate change and adaptation measures at the local level.	-1	-3	0	-1

Findings show that both horizontal and vertical dimensions of multi-level governance have been severely criticised by the participants. On the one hand, there is not enough leadership in the complex process of adapting road transport sector to climate change impacts (S3) to facilitate the process of translating the national strategies to the local initiatives and actions. On the other hand, there is not a good working relationship between the transport (DRD) and environment (DOE) departments with respect to climate change adaptation issue (S5).

The scores given to statements S12, S9 and S34 in four attitudes strongly highlight the negative impact of inappropriate funding mechanisms in achieving a resilient road transport network in Belfast. Results from the Q methodology confirms the findings from the interviews regarding the reactive approach of road transport authorities in dealing with climate change impacts. Participants criticise the existing government approach in prioritising road transport projects which provides less opportunities for implementing and delivering sustainable transport measures and objectives (S9). Similar to the qualitative findings, results from the Q methodology certify that politicians have a strong influence on transport-related decisions, and their interests are not necessarily consistent with the actual needs of the public (S27).

Findings show that there is not an effective consultation process about transport policies. As discussed extensively in Chapters 4 and 5, and partly confirmed by four negative scores for statement S27, there is a need to improve the effectiveness of the consultation process to provide more opportunities for different stakeholders to influence transport decisions. The gaps in existing policy documents such as specifications, standards, etc. have also been underlined in all four attitudes (S32). Hence, a good consultation approach will enable transport decision makers to make effective and efficient decisions when there are not enough guidelines for integrating climate change and transport policies.

In addition to the factors participants have a high level of consensus about, five other factors have received a great attention by them as shown in Table 6-2. Firstly, the scores given to these five statements confirm the lack of leadership at the national level (S1). Secondly, although there are some contradictory opinions about political will and support, the dominant view is that the long-term benefits of climate change activities are not motivating politicians to mainstream climate change in their decision making process (S16 and S20). However, as indicated by statement S19, it can be concluded that the local stakeholders have enough motivation to include climate change adaptation in their agenda although they do not have enough authority and power. On the other hand, the dominant view is that there is not sufficient public demand for climate change adaptation which is another reason for politician's lack of willingness (S29).

Table 6-2: Consensus between extracted factors, Belfast (high consensus)

No	Statement	A	B	C	D
16	Financial benefits of the climate change adaptation cannot persuade politicians to implement the climate change adaptation policies.	+2	-2	+1	+3
29	There is not sufficient public demand for climate change adaptation.	0	+3	-1	+2

1	Roles and responsibilities for climate change adaptation are not clear across levels of government	-1	0	3	1
20	A lack of political will and support has slowed down the process of climate change adaptation.	2	1	1	-1
19	Local/regional authorities should give higher priority to climate change on their agenda.	-1	2	-2	-2

6.2.4 Empirical Findings in Cambridge Case Study

6.2.4.1 Qualitative Data: Interviews

Like participants from Belfast, Cambridge participants highlighted the need for giving a higher priority to road maintenance in addressing climate change. However, unlike participants from Belfast, participants from Cambridge city placed equal emphasis on two negative aspects of climate change, i.e. increased rainfall and increased air temperature. Increased cost of road maintenance as a result of increased air temperature in summers, and a modal shift from sustainable modes of transport towards private car use as a result of increased rainfall in winters were the most frequently raised concerns during the interviews in Cambridge.

Almost all participants in Cambridge acknowledged that climate change adaptation has been considered during road design process. Implementing climate change adaptation measures in new roads and road maintenance activities, and paying a good attention to the sustainable modes of transport are some of the measures that were highlighted in interviews although there were concerns about the lack of attention paid to the 'long-term' impacts of climate change. However, the main concern of participants is about the lack of integrated land-use and transport planning in recent years. It was underlined that as a result of expensive housing price in Cambridge in recent years, there is a growing number of people who are working in Cambridge and living in newly developed areas such as in Cambourne, St Neots, Papworth, etc. Since there is not sufficient funds to provide the public transport services between Cambridge and these areas, not only has the percentage of private car use increased, but the average travel distance to work has also increased.

The lack of financial resources for transport to implement sustainable transport objectives was strongly emphasised by the majority of participants. The growing population of people living in the newly developed areas was considered to be the main reason for the need for more financial resources in delivering sustainable transport objectives. According to the discussions, both the city and county councils are under huge financial pressure to employ the required expertise and implement climate change and sustainable transport policies. However, like Belfast, participants from Cambridge also criticised different aspects of the existing funding mechanisms for transport investment and projects. Firstly, it was underlined that there is not a long-term transport planning framework since the transport authorities receive their funds from the government with tight deadlines, as a result, the common way of investing the received money is to construct a new road or invest in smaller projects without considering the actual cost-benefit of the projects within whole life cycles. It was also argued that the national government is shifting all responsibilities related to climate change adaptation policies to the local authorities without providing a specific source of funding to implement those decisions.

Findings show that the socio-political barriers are the second most important set of barriers in Cambridge after economic barriers. Unlike Belfast where political barriers were perceived to be significant at the national level, in Cambridge political barriers at the local level were recognised to be more significant. Participants related this issue to the level of the public support for climate change policies which consequently hampers the cooperation between Cambridge City Council and Cambridgeshire County Council. It was highlighted that there is a wide gap between the attitudes of the public who are living in Cambridge with those who are living in rural or small urban areas. According to the discussions, there is a good support for climate change policies within the Cambridge city region area but it decreases in outer areas. This provides a complex atmosphere for politicians and transport authorities to address different concerns of the public who are living in different areas.

Participants were of the common opinion that there is not a clear view from the national level about climate change adaptation. It includes the lack of design specification about climate change adaptation measures in road transport sector, and the lack of guidance for monitoring the progress of climate change adaptation process. Combined with financial constraints, this issue has had a direct impact on the quality of the local adaptation action plans. However, a participant took this as a positive point considering that most of the city region areas in the UK still have not developed their initial adaptation action plans. The disconnection between transport and land-use policies in the last decade was frequently criticised in the discussions. It was argued that the sustainable modes of transport did not receive enough attention from transport and planning authorities. However, one participant was optimistic that recent changes in the assessment and monitoring of the travel plans of organisations will have a positive impact on moving towards the sustainable modes of transport.

With respect to the participation in transport decisions made in Cambridge, it can be concluded that although there has been a mechanism for the public or pressure groups to be involved in the process but the county council is not proactive in listening to other stakeholder's concerns. It was argued that the county council consults only when it is legally required to do so. Similarly, regarding the transparency and accountability issues, according to the discussions, the existence of a two tier model at the local level makes it difficult for the public to clearly recognise the responsible council. Participants from the city council shared their concerns regarding the accountability of transport decisions. They argue that due to the lack of transparency in the county council, a majority of the public consider the city council as the responsible body for all issues in the city region areas. They discuss their transport related concerns with the city council. The city council, therefore, has to allocate a huge amount of its limited funds to address their concerns such as subsidising the public transport.

Findings show that there are a lot of political barriers in the way of establishing a new single tier local authority in Cambridge although it is clear for all stakeholders that the creation of such a transport governance arrangement would have an influential role in increasing the transparency, improving the accountability and the effective and efficient delivery of sustainable transport policies within the city region area. However, it is not clear from the findings whether or not establishing a new transport governance arrangement can lead to the effective implementation of policies at the county level.

6.2.4.2 Q-methodology Findings

Results of the Q methodology confirms the findings of qualitative interviews with respect to the current progress of climate change adaptation in road transport sector. As discussed in Chapter 5 (see statement S34), the first two factors which have the higher eigenvalues consider the current progress to be a proactive adaptation although factor C and D faintly disagree with this statement. Table 6-3 shows the areas which participants load in four extracted factors have a high level of consensus over them.

Findings show that similar to the Belfast case study, participants from Cambridge are concerned about the conflict between the long-term nature of climate change and short-term electoral cycles (S30). However, participants in Cambridge have supported this view with much more emphasis on the lack of political support from national politicians (see S35 in Table 6-4). All four attitudes among Cambridge participants confirm that local transport authorities have enough motivation in integrating climate change adaptation policies within transport-related decisions (S19). In addition, all attitudes confirm that there is enough public demand for climate change activities at the local level (S29).

Findings of the Q methodology in Cambridge are consistent with the findings of the in-depth interviews. As shown in Table 6-3, the lack of financial resources and inappropriate funding mechanisms are the main problems of stakeholders in dealing with climate change issue in road transport sector. According to the final scores, it can be concluded that the local authorities do not have money to recruit the required expert staff to help them integrate climate change and transport related policies (S10, see S11 in Table 6-4). In addition, as highlighted during the interviews, there are not sufficient financial incentives for the local transport authorities to mainstream climate change within their departmental decisions (S28). Moreover, findings show that the unclear approach of the national government in addressing climate change has not prepared a good business case for private sector to take part in climate change adaptation process (S2).

Table 6-3: Consensus between four extracted factors, Cambridge (all agreed/disagreed or neutral)

No	Statement	A	B	C	D
2	Roles and responsibilities for climate change adaptation are not clear between the public and private sector.	0	1	2	3
30	The tension between short-term electoral cycle and long-term nature of climate change has reduced the political will.	1	0	3	1
17	There is discretionary power for the local/regional level actors to prioritise the implementation of the transport projects.	2	0	2	0

29	There is not sufficient public demand for climate change adaptation.	0	-1	0	0
28	Adequate financial incentives are available for transport authorities to adapt the transport sector to climate change.	-1	0	-1	0
19	Local/regional authorities should give higher priority to climate change on their agenda.	-1	-1	0	-2
10	Local transport authorities have adequate resources to recruit required climate change experts.	-2	-2	-3	0

The scores given to the other statements in Table 6-4 provide more evidence about the above mentioned concerns of Cambridge participants. Statement S18 confirms that there are political barriers in terms of acceptance of climate change. However, this issue received less scores than that statement S30 did which shows that politicians are more interested in the implementation of the measures which need shorter time for return upon the investment. Considering all of these economic-political factors it can be concluded that it is necessary to have short-term (and much clearer) objectives for climate change adaptation policies to motivate politicians to include climate change adaptation in their decision making process.

In the economic dimension, it can be concluded that the existing funding mechanism for transport projects does not consider the long-term cost and benefits of available options (S33). This can be partly the consequence of the lack of guidelines and specifications for climate change adaptation which makes it difficult for the local transport authorities in dealing with uncertain climate change impacts (S32). Hence, the existence of a long-term national financing framework for funding climate change adaptation activities seems to be necessary.

Table 6-4: Consensus between extracted factors, Cambridge (high consensus)

No	Statement	A	B	C	D
18	The scepticism of politicians on the existence and importance of climate change are a significant barrier in the way of effective climate change adaptation.	3	-1	3	-1
33	The existing financing mechanism permits decision makers to secure project approval and funding through under-estimating the long-term cost of the project.	1	2	2	-2
11	Local transport authorities have adequate expert staff to deal with the impacts of climate change on the road transport system.	-1	-1	-3	2
32	For the purpose of evaluation and monitoring, there are adequate information and guidelines available about the climate change and adaptation measures at the local level.	-2	-1	-2	2
35	Devolution of transport powers, from the national/regional level to the local level, increases the degree of political influence on decisions.	-3	-2	-2	3

6.3 Recommendations

This section presents the policy implications from the research. It should be highlighted that this section suggests those recommendations that their reliability have been tested with both qualitative analysis (in-depth interview) and quantitative analysis (Q methodology). As discussed extensively in Chapter 4 and Chapter 5, in both case study areas, there are some factors which their influence was not agreed with the majority of participants/factors highlighting that this research was not able to make a solid recommendation about them. However, the following sections identifies the common cause for different barriers of climate change adaptation, and gives recommendations which can improve the efficiency and effectiveness of the policy implementation process. It should be highlighted that, although Chapters 4 and 5 has provided the researcher with rich information in finding the cause of barriers, ultimately these causes are determined through the researcher's judgment from the review of the literature, interview scripts, policy documents and Q methodology findings.

6.3.1 Belfast

Findings showed that the integration of climate change adaptation policies within Belfast road transport sector is mostly suffering from socio-political, institutional and economic set of barriers. These barriers are due to a lack of political will and support, a lack of public demand for climate change adaptation, a lack of national leadership, a lack of joined up thinking at departmental level and an inappropriate financing mechanism.

Figure 6-1 highlights the main barriers perceived by the study participants considering the causes for these barriers and proposes four recommendations to improve the integration of climate change adaptation and transport policies.

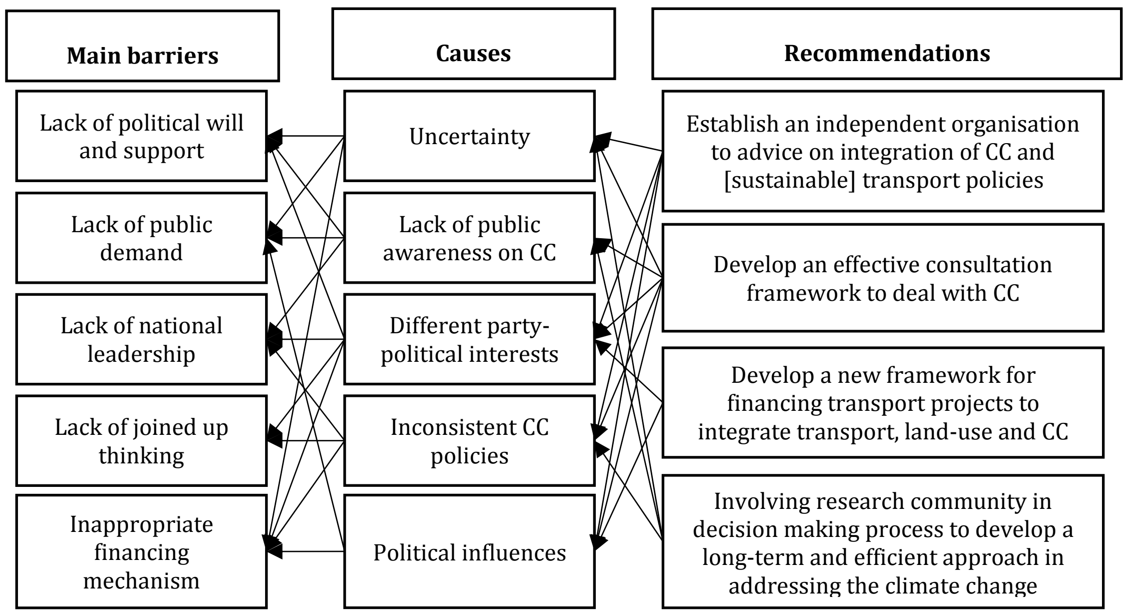


Figure 6-1: Barriers for climate change adaptation, causes and recommendations, Belfast

The first recommendation is to establish an independent organisation to advise the government, especially at the national level, on the development and implementation of climate change adaptation policies. On the one hand, as discussed in Chapters 4 and 5, the existence of the uncertainties have created an irrational atmosphere around climate change adaptation policies which can decrease the political will and support. Participants frequently raised their concerns regarding the politicians' disbelief about climate change by even Minister of the environment. On the other hand, according to the findings from the interviews and the Q methodology, politicians have a strong influence on transport decisions. Moreover, the consultation process for transport-related projects and investments was not recognised to be effective. Hence, it is not surprising when participants argue that the current progress in adapting road transport sector to climate change impacts is not satisfactory.

The second recommendation is to develop an effective consultation process for transport projects and investments. Transport projects will be in operation for decades; hence it is necessary to assess, as much as possible, the long-term cost and benefits of them. Considering the complex process of climate change adaptation and existence of uncertainty about future projections, it can be asserted that this aim cannot be fulfilled without involving all stakeholders in decision making process. However, findings of this research show that the existence of political conflicts between different political parties is impacting the consultation process. In other words, the existing consultation framework is not effective during political tensions among different political parties. It is strongly recommended to introduce a new consultation framework which can be effective even when there are a high level of tensions between different stakeholders.

The third recommendation is related to the better integration of transport and land-use planning by considering climate change mitigation and adaptation.

Findings of this research show that the focus of transport authorities on the construction of new roads is hampering the implementation and delivery of sustainable transport objectives in Belfast area. This issue will be intensified when considering climate change and its projected impacts. The construction of new roads increases impermeable surface areas and can lead to more severe flooding in road networks. In addition, due to the lack of integrated approaches for transport and land use planning the existing road networks have been frequently adjusted to new situation usually by adding a new lane to accommodate the increased road users. In this situations the width of road shoulders have been reduced consequently it can increase the vulnerability of the roads to climate change impacts. It can be concluded that not only is not there an effective and long-term integrated transport and land-use planning approach but also climate change adaptation issue is not considered when designing a new road.

The fourth recommendation is not completely different from the second one (effective consultation). However, considering the uncertain nature of climate change, it is important to emphasise again that the implementation of climate change adaptation without involving research communities will not be possible. Climate change policy developers in the UK have a good evidence regarding the progress of climate change mitigation policies. The current progress in climate change mitigation and reduction of greenhouse gas emissions would not have been possible without involving research communities. Developing new technologies in all sectors for the efficient use of energy is still an active area for researchers and private sectors. Increasing the role of academia in decision making of climate change adaptation policies can lead to develop much more effective and efficient approaches in addressing the impacts of climate change and can initiate a new horizon for public private partnership.

6.3.2 Cambridge

Cambridge, using as a decentralised transport governance model, has experienced different obstacles in the implementation of climate change adaptation policies in road transport sector. Although, there are similar concerns regarding the lack of political will and support at the national level, in comparison to Belfast, participants in Cambridge were not pessimistic about the local politicians' attitudes towards climate change. The main political barrier perceived by the study participants is related to the conflict between the long-term nature of climate change and short-term electoral cycles. The most emphasised barriers were the lack of financial resources to implement climate change adaptation measures as well as the lack of guidelines and specifications in connecting the national climate change strategies to the local needs. According to the findings in Chapters 4 and 5, three main recommendations can be made as shown in Figure 6-2.

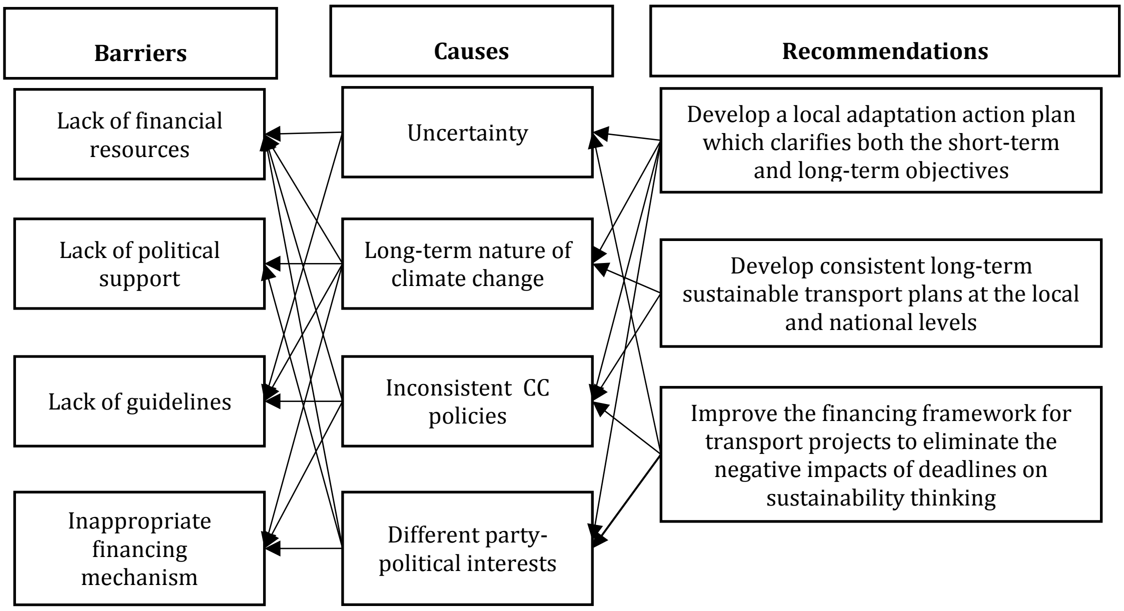


Figure 6-2: Barriers for climate change adaptation, causes and recommendations, Cambridge

According to the findings from Chapters 4 and 5, the first recommendation for the local transport authority is to develop a climate change adaptation action plan which clearly defines the short-term and long-term objectives. As discussed above, the only strong political barrier in Cambridge case study area is that the long-term nature of climate change is increasing the reluctance of politicians in moving towards sustainable and climatic resilient road transport system. Defining short-term objectives can address this concern by providing opportunities for politicians in convincing the public about their efforts in addressing climate change. On the other hand, defining long-term objectives is necessary to guarantee that changing the composition of the local politicians cannot have significant impacts on the progress of climate change adaptation.

The second recommendation is related to the increase in consistency between the local and national sustainable transport plans. Participants shared their concerns about the disconnection between policy documents across the scales of governance. It was highlighted that the national transport authorities are just shifting the responsibilities to the local level without considering the actual needs at the local level. Hence, a better coordination between the national and local transport authorities is necessary in a better delivery of the national strategies' objectives to the local actions.

It was strongly agreed by almost all participants that the existing financing mechanism is not helping the local authorities to integrate sustainable transport planning and the current growth into the land-use. Cambridge as a compact but fast growing city is not able to accommodate new residents within its border; hence there are currently growing number of people who live outside the city and work inside the city. Placing a tight deadline for the available funds from the national level does not give any opportunity for the local transport decision makers to integrate sustainable transport and land-use planning. Within the current financing mechanism, there is no doubt that investing a fixed amount of money on a new dual carriageway is quicker than spending that money on the maintenance of existing roads or investing on cycle roads. Hence, the third recommendation is to develop a new national transport financing mechanism which allocates more weights to sustainable transport objectives and gives more time for the implementation of sustainable transport measures.

6.4 Contribution to Knowledge

This research is unique in terms of employing the Q-methodology to investigate the relationship between transport governance arrangements and the implementation of climate change adaptation policies. Although the importance of effective and efficient governance arrangements in the process of the implementation of climate change adaptation and sustainable transport policies had been recognised in previous studies but there are only a few studies which effectively linked the findings of their research to policy implementation theories. Different theories in policy implementation emphasize the role of consensus building in the successful implementation of a policy. However, the literature review shows that there is not a widely accepted method for measuring the level of consensus among different stakeholders involved in the policy cycle. In addition, although the theories in policy implementation, especially the Advocacy Coalition Framework (ACF) developed by Sabatier (see Chapter 2), have highlighted the role of "*belief systems*" in the process of policy implementation, the current methodological frameworks were not able to systematically recognise or cluster different belief systems. An innovative methodology used in this research which involves the combination of the Q methodology with Monte-Carlo simulation and Artificial Neural Network has bridged these two gaps in the policy implementation literature.

On one hand, the current study was able to cluster different stakeholders by extracting their main attitudes in terms of the implementation of climate change adaptation policies within the road transport sector. Using the Q factor analysis and Varimax rotation function, the Q methodology as a classification method was used to systematically extract the main attitudes of different stakeholders. This method enabled us to bridge the gap between theoretical and methodological frameworks in the policy implementation literature. On the other, this research enriches the literature of the Q methodology by investigating the role of different factors in research design and re-engineering the different steps of the Q methodology. This contribution has at least two benefits i.e. one for the Q methodologists, and another for policy analysts.

Firstly, this research provides Q methodologists with a detailed understanding about different steps of the Q methodology and help them design a more targeted research at the initial phase of empirical studies. This involves, but not limited to, the recommendations about the sample size, the shape of sorting sheet, the relationship between sample size and the number of statements and most importantly estimating the level of consensus among participants. Clarifying the relationships between different parameters influencing the results of the Q study, this study enabled us to have an outstanding contribution to the existing knowledge on estimating the reliability of the Q study.

Secondly, combining Monte-Carlo simulation and Artificial Neural Network analysis in this research enabled the researcher to fill another gap between theoretical and methodological frameworks in the policy implementation literature. The importance of the level of consensus among different stakeholders involved in the policy implementation process has been emphasised in almost all policy literature. The current empirical study has also highlighted this factor during the interpretation of the findings. This can be found in different forms for example, complex policy implementation process, lack of joined up thinking among stakeholders, etc. However, within the reviewed literature there was no method to explain how much this complexity or lack of joined-up thinking differs from other studies. In other words, the qualitative approach used by previous policy analysts does not provide the researcher with an accurate measure to compare the level of complexity for the implementation of a specific policy or the level of consensus among stakeholders involved in the process. The methodological framework introduced in this research not only enables the policy analysts to have more accurate and valid tools in measuring the level of consensus in their study but also it provides them with a very simple and straightforward formula to compare the findings from their Q study with respect to the level of complexity of the policy under investigation with the findings of other Q studies even with different number of statements or different sample sizes. Hence, a study which had done a while ago can be conducted today with new adjustments in the Q set, sample size, etc. allowing the researcher to track the progress of the policy implementation with time.

This research contributes to the existing knowledge on the effectiveness of the transport governance arrangements in the implementation and delivery of climate change adaptation policies. Although in the last decades, researchers have considered climate change at the heart of sustainable transport but the literature review shows that climate change adaptation has not received enough attention. Hence, climate change mitigation and the reduction of greenhouse gasses are the main focus of the existing sustainable transport literature. As predicted in the past, the issue of climate change has been linked to a variety of economic and political matters at the international levels. Addressing climate change, therefore, through only mitigation cannot and could not be possible. As discussed in Chapter 1 and Chapter 2, this can be partly related to the fact that transport sector usually has had and still has a large contribution to greenhouse gas emissions. The focus of this research on the implementation of climate change adaptation can provide a unique insights into opportunities and challenges that transport stakeholders are facing with respect to adapting road transport sector to new climatic situations.

On the other hand, despite the recent shifts in policy implementation styles from national and centralised modes of governance to participatory and localised modes, the focus of climate change adaptation (especially in transport sector) has remained on the challenges that national government are facing in developing climate change adaptation policies including financial barriers, scientific barriers and issues related to power distribution models. Although those research have provided informative recommendations regarding the risk assessment process, awareness raising and national/regional economic-political factors but there is a gap in the current literature regarding assessing the role of local factors in the process of climate change adaptation in the context of road transport sector. This research contributes to existing knowledge by investigating the importance of those factors which transport stakeholders recognise as important at the local level.

Furthermore, this research investigated the effect of two different transport governance models in the effectiveness of the implementation of climate change adaptation policies. Belfast represents a centralised transport governance model where almost all transport related powers have been collected in Department for Regional Developments. And Cambridge represents a decentralised transport governance structure where the local governments, a two tiered model, are responsible for all local roads excluding motorways. By employing the Q methodology in two case study areas and comparing the areas of consensus and differences on the aspects of climate change adaptation at the local level, this research introduces a robust methodological framework to investigate the consistent challenges that transport stakeholders are facing in both centralised and decentralised transport governance models.

6.5 Research Opportunities

Findings from different phases of this research highlighted several knowledge gaps which needed to be investigated. This section summarises these areas in three sub-sections. Section 6.5.1 makes recommendations for Q-researchers who are interested in contributing to the improvement of the Q methodology specifically regarding increasing the reliability of this methodology. And finally, Section 6.5.2 involves the knowledge gap related to the better integration of climate change adaptation policies within sustainable transport governance.

6.5.1 For Q Methodologists

This research investigated the role of transport governance arrangements in successful implementation of climate change adaptation policies within the road transport sector at the city level. In order to explore different variables and find the relationship between these variables, the Q methodology as a mixed method was employed in two case study areas i.e. Belfast and Cambridge. The Q methodology as a quantitative part of this research was able to clarify the correlations between different variables in the extracted attitudes. The final output of a Q methodology are some scores assigned to different statements in each attitude which enabled the researcher to make a comprehensive comparison between the findings in two case study areas. On the other hand, according to Chapter 3, almost all questions considered for policy analysis purpose usually are complex and can be represented by qualitative type of questions (i.e. why? How?). Moreover, the review of literature surrounding the policy implementation theories (see Table 3-1) shows that the qualitative approaches (e.g. interviews and focus group discussions) have received more attention by policy analysts than others. It should be emphasised that the Q methodology used in this research should be considered as a qualitative method since it collects required data through qualitative Q sorting process although it benefits from the quantitative methods during the data analysis.

But the main question here is that whether or not separating different factors in the Q methodology (during the Q set generation) is able to represent the complexity of policy implementation process in the real world. In other words, can the Q methodology manage the inter-correlation between different themes, e.g. transparency, stakeholder participation, political will and support, etc. in the final interpretation of the results? Although the Q methodology offers many advantages over other qualitative methods (such as interviews and focus group discussions) but the reality is that Q researchers are not allowed to make a complex Q set. In other words, each statement in the Q set (ideally) is representing only one pure variable. Considering the data analysis methods used in Q methodology, it becomes clearer that why this assumption exists and why it is correct. The Q uses Principal Factor Analysis (PCA) for classification. The PCA is based on the perpendicular vectors (eigenvectors). Hence, (theoretically) the correlation between any two statements within the Q set should be zero, or in other words, each statement must represent a unique factor. But apparently this is a disadvantage for Q methodology since it does not allow the researcher to have complex statements. Further research is required to investigate the role of replacing the PCA with alternative factor analysis methods. For example, although the PCA is the most frequently used factor analysis method within Q literature, centroid method has also been used by some scholars. Since, in centroid method, factors are not considered to be perpendicular, it could give more flexibility to researchers in designing the Q set.

Along the same line, the literature review shows that there is not any Q literature which justifies the assumption that different attitudes should be perpendicular to each other. In other words, in the Q methodology (which uses PCA), the first assumption is that different attitudes cannot have any similarity with each other and they always should reject each other. The only justification for this is that the Q is able to find ‘unique’ viewpoints, however, it seems not to be a correct reasoning. By employing the PCA method and trying to make ‘unique’ attitudes, it is not clear that whether the final factors are reflecting the real attitudes. Removing this limitation from the Q methodology not only can give an opportunity to a Q researcher to better represent a complex policy implementation process in a limited number of statements but also it will lead to extract non-vertical attitudes about the topic of the study which seems to be more realistic.

6.5.2 For Climate Change and Sustainable Transport Researchers

This section proposes two important research areas for future researchers who are interested in the subject of sustainable transport and climate change adaptation. Firstly, as discussed in the last three chapters, it became clear that uncertainty about climate change impacts is showing itself in almost every stage of the implementation of climate change adaptation. It can decrease the public demand and political will, it hampers the financing mechanism and as a whole it is able to bring irrationality to the context of climate change policy. Hence, it is required to investigate the possible ways that can help transport decision makers to deliver sustainable transport objectives within an uncertain (climatic) situation. The proposed research should look at different aspects of policy implementation process from different viewpoints such as socio-political, economic and scientific with particular emphasis on the multi-level financing mechanism of transport projects.

Secondly, the literature review on public policy implementation and empirical studies conducted in the context of sustainable transport policies shows that there is still not a robust methodology to investigate the integration of different factors/dimensions/themes which are influencing the outcome of a transport-related policy. It is common among researchers to emphasis on the role of the integration between (for example) transport planning and land-use planning, or the integration between transport policies and climate change policies. However, there is not a widely accepted method as a baseline to be chosen by researchers when investigating the role of the integration of two different policies on achieving the objectives of sustainable development. Developing such a methodology can be beneficial for transport research communities. It makes it possible for researchers to have more benefits from the studies conducted before. For example currently there are many literature which discuss the integration of transport and land-use policies. However, when a new researcher is interested to continue to work on those areas, he/she will need to redo most part of previous research and finally when findings are a bit different from what have been obtained in the previous studies, there is not a systematic way to investigate the cause of differences between different studies since each of them has chosen different methods and different assumptions. Hence, it is required to develop a methodological framework which is able to consider different aspects of sustainable transport. Developing a new 'adaptable' method for the integration of transport and non-transport polices can be like a semi-standard methodology in which researchers need to consider some assumptions (limitation) and at the same time is flexible enough to allow them to bring new ideas.

Appendixes

Appendix A-1: Step by Step Q Factor Analysis

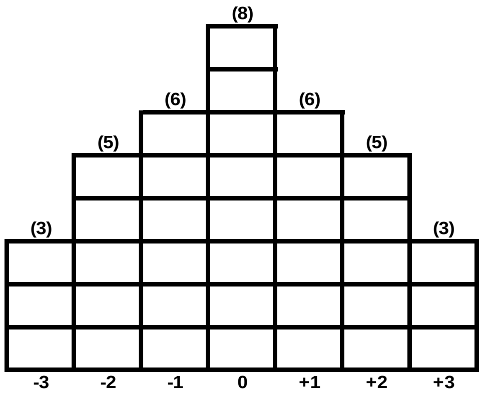
In this section a complete and step by step Q factor analysis on a Q sorting matrix is presented (See Example 1 in Section 3.12.2.1). Suppose that 25 participants (Group 1: P1, P2… P25) have sorted 36 statements about topic A on a symmetric sorting sheet (SSS) as shown in Table A-1 which is a 36×25 matrix. Figure A-1 shows the forced distribution sheet. The aim is to find out the attitudes (factors) among participants who are able to explain at least 50% of the study.

Step 1: Calculation of the correlation matrix

According to Watts and Stenner (2012, p.97) "*correlation matrix is created through the intercorrelation of each Q sort with every other sort*". Hence the correlation matrix (25×25) is calculated as shown in Table A-2.

Step 2: Factor analysis

In this step, factor analysis is undertaken on the correlation matrix (Table A-2). In this example, Principle Component Analysis (PCA) approach is used. Table A-3 shows all of the extracted factors which explain 100% of total variability in the correlation matrix. Each latent factor has a corresponding eigenvalue. The larger the eigenvalue of a factor, the more important that factor is. However, since the Q methodology is a data reduction approach it is only required to keep a few number of important factors (larger eigenvalues) to be used in factor rotation step.



(a) SSS1

Figure A-1: distribution sheet for a 36-item Q set (SSS1)

Table A-1: Q sorts based on Table 1 and SSS1 (NP=25 participants, NS=36statements)

S / P	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21	P22	P23	P24	P25
S1	-1	-1	0	1	0	0	-1	-2	1	0	2	2	-3	1	-2	-3	-2	2	-2	-2	1	0	2	3	0
S2	0	-3	2	0	-1	-3	3	-3	0	1	0	3	1	0	3	0	2	2	-1	-3	-1	-3	0	0	-3
S3	-2	2	2	-3	1	-1	3	-1	-3	-1	-2	1	0	0	-3	-1	-1	3	1	0	2	2	-1	-2	-2
S4	1	0	-1	2	-2	0	0	-3	-2	1	0	2	-2	2	1	1	2	3	-1	0	-2	3	1	-3	0
S5	3	0	2	0	1	0	-2	2	-1	-2	-1	-1	1	-2	2	-1	2	-1	-3	2	0	0	0	0	1
S6	-1	1	2	3	-3	0	-1	0	-1	1	-1	-1	0	2	1	0	-2	0	-2	-2	1	-3	-1	3	0
S7	0	-2	1	0	2	-1	0	0	-3	-2	1	0	0	-3	0	2	2	0	2	0	-3	1	-2	0	-2
S8	0	0	-2	-1	-2	3	2	-1	2	1	-1	2	-1	1	2	-2	-1	-3	2	-1	1	-1	1	3	-3
S9	-1	2	-3	-2	2	1	-2	1	0	-2	-2	0	0	0	1	1	0	1	0	0	-2	1	1	2	-1
S10	0	-2	0	1	0	0	-1	1	2	0	-3	1	-3	-1	-3	-1	3	-2	2	-1	1	-3	0	0	1
S11	3	1	-1	0	3	-1	2	0	1	-3	-1	1	0	2	2	-2	1	2	-1	-1	-3	-1	2	1	2
S12	-1	0	-1	0	2	2	-1	-2	0	1	3	-1	0	-2	-1	3	0	0	0	-2	0	0	-1	-1	-1
S13	-2	-2	3	-1	3	1	1	3	-2	0	1	1	3	-2	-2	-1	0	0	2	0	0	1	-3	0	1
S14	-1	3	0	-1	2	1	2	0	-1	-3	1	-2	1	2	1	0	1	1	-3	1	-2	-1	-3	-1	3
S15	1	-1	-2	-1	-3	-3	-3	-2	0	0	-3	1	-2	-2	0	1	2	-1	-2	1	1	-2	2	-1	-2
S16	1	2	0	-3	-3	0	1	-1	0	3	-1	0	-1	-1	-2	3	3	-3	0	2	-2	0	0	-3	-1
S17	-3	1	1	-3	-2	1	-1	3	-1	-2	0	2	2	-3	-2	2	0	-3	3	1	0	2	0	1	1
S18	2	2	-2	-1	1	1	-3	0	2	2	1	1	3	0	-1	-3	1	-2	1	2	0	1	0	1	0
S19	2	-1	3	1	-1	2	-2	0	2	-1	2	-2	-1	1	0	0	-1	1	-3	-2	-1	2	-2	-1	-3
S20	0	-1	0	1	-1	1	0	2	-2	2	0	-3	-1	2	-1	0	-2	3	3	0	0	-1	-2	0	0
S21	-3	2	-2	0	0	2	0	-1	-2	2	2	-2	0	-1	2	2	1	-1	0	-1	3	2	3	-1	0
S22	0	1	-3	1	-2	-2	-3	0	3	0	-3	3	-1	1	1	-1	-3	-2	1	1	1	0	-2	0	3
S23	2	0	0	1	0	3	1	-2	-2	-1	0	-2	1	-3	0	2	0	1	-1	0	-2	-2	1	2	-1
S24	-1	-2	3	3	0	-1	3	-1	1	-3	-1	-3	2	3	0	1	-2	-1	-2	2	3	3	0	-2	0
S25	0	0	2	3	2	2	-2	1	3	3	0	0	2	3	0	-2	0	0	0	-1	2	-2	3	2	2
S26	2	-1	1	-1	-1	0	1	0	0	-1	3	-1	-3	0	0	3	1	1	2	3	-1	1	-3	-3	3
S27	1	3	-1	-2	0	3	1	-2	3	2	2	-2	1	-2	1	0	-3	-2	1	-2	2	-1	3	0	-1
S28	-2	-3	1	2	1	-2	-2	1	1	1	0	3	1	-1	-3	1	-3	-2	-1	3	3	0	-2	-2	2
S29	-3	1	-1	0	-2	-2	2	1	2	3	-2	2	-2	0	0	-1	-1	2	1	3	2	0	1	1	2
S30	0	-1	-3	2	-1	2	0	1	-1	2	1	0	2	-1	-2	-3	-1	2	0	-3	2	-2	-1	1	1
S31	3	0	1	0	1	-1	1	2	1	0	3	-1	-2	0	3	-2	1	-1	-2	-1	-3	-2	-1	-2	1
S32	-2	-2	-1	2	3	-3	0	3	0	0	-2	0	0	1	-1	2	0	0	0	-3	-1	-1	0	1	0
S33	1	0	1	2	1	-2	2	2	-3	-1	2	-1	3	3	3	0	-1	-1	-1	2	0	1	1	2	-1
S34	1	3	-2	-2	-1	0	0	-3	-1	-2	-2	-3	2	1	2	1	3	0	1	1	-1	0	2	2	2
S35	-2	-3	0	-2	0	-1	0	2	1	0	0	0	-2	0	-1	-2	-2	1	0	0	-1	2	2	-2	-2
S36	2	1	0	-2	0	-2	-1	-1	0	-1	1	0	-1	-1	-1	0	0	0	3	1	0	3	-1	-1	-2

Table A-2: correlation matrix

Correlation	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21	P22	P23	P24	P25
P1	**1.00**	0.12	0.00	0.01	-0.02	0.06	-0.10	-0.23	0.12	-0.18	0.18	-0.24	-0.08	0.05	0.40	-0.13	0.35	-0.03	-0.22	0.06	-0.47	-0.17	0.00	-0.07	-0.05
P2	0.12	**1.00**	-0.39	-0.44	-0.09	0.34	0.01	-0.25	-0.01	-0.01	-0.04	-0.25	0.17	0.06	0.25	0.04	0.11	-0.12	0.06	0.15	-0.05	0.09	0.24	0.16	0.19
P3	0.00	-0.39	**1.00**	0.19	0.16	-0.10	0.26	0.22	-0.17	-0.22	0.24	-0.14	0.16	0.08	-0.10	0.06	-0.06	0.08	-0.22	0.07	0.01	0.11	-0.34	-0.22	-0.10
P4	0.01	-0.44	0.19	**1.00**	0.07	-0.08	-0.10	0.09	0.08	0.15	0.03	-0.06	0.08	0.47	0.10	-0.13	-0.27	0.16	-0.40	-0.23	0.25	-0.27	-0.04	0.21	0.21
P5	-0.02	-0.09	0.16	0.07	**1.00**	0.03	0.08	0.34	-0.10	-0.33	0.25	-0.13	0.36	0.01	-0.03	-0.11	0.03	0.14	-0.06	-0.14	-0.21	0.07	-0.08	0.07	0.14
P6	0.06	0.34	-0.10	-0.08	0.03	**1.00**	-0.06	-0.09	0.05	0.18	0.37	-0.39	0.21	-0.15	-0.04	-0.04	-0.08	-0.08	0.10	-0.26	0.07	-0.04	0.11	0.24	-0.03
P7	-0.10	0.01	0.26	-0.10	0.08	-0.06	**1.00**	-0.13	-0.28	-0.14	0.11	-0.15	0.08	0.21	0.23	0.05	0.02	0.28	0.02	-0.04	-0.10	0.01	-0.01	-0.12	-0.10
P8	-0.23	-0.25	0.22	0.09	0.34	-0.09	-0.13	**1.00**	-0.03	-0.06	-0.01	0.03	0.16	0.00	-0.21	-0.20	-0.20	-0.15	0.17	0.13	-0.02	0.01	-0.30	0.08	0.30
P9	0.12	-0.01	-0.17	0.08	-0.10	0.05	-0.28	-0.03	**1.00**	0.28	-0.12	0.25	-0.24	0.17	-0.01	-0.38	-0.26	-0.34	-0.04	-0.07	0.25	-0.22	0.23	0.08	0.15
P10	-0.18	-0.01	-0.22	0.15	-0.33	0.18	-0.14	-0.06	0.28	**1.00**	0.08	0.22	-0.11	-0.03	-0.18	-0.15	-0.15	-0.08	0.20	-0.18	0.40	-0.28	0.21	0.01	-0.07
P11	0.18	-0.04	0.24	0.03	0.25	0.37	0.11	-0.01	-0.12	0.08	**1.00**	-0.30	0.09	-0.09	0.11	0.05	-0.11	0.08	-0.08	-0.15	-0.13	0.20	-0.18	-0.18	-0.07
P12	-0.24	-0.25	-0.14	-0.06	-0.13	-0.39	-0.15	0.03	0.25	0.22	-0.30	**1.00**	-0.19	-0.13	-0.24	-0.28	-0.04	-0.08	0.17	0.03	0.10	-0.06	-0.01	0.06	0.01
P13	-0.08	0.17	0.16	0.08	0.36	0.21	0.08	0.16	-0.24	-0.11	0.09	-0.19	**1.00**	0.00	0.09	-0.03	-0.07	-0.20	-0.02	0.06	0.15	0.05	0.00	0.30	0.08
P14	0.05	0.06	0.08	0.47	0.01	-0.15	0.21	0.00	0.17	-0.03	-0.09	-0.13	0.00	**1.00**	0.32	-0.30	-0.23	0.28	-0.28	-0.03	0.05	0.01	0.08	0.14	0.20
P15	0.40	0.25	-0.10	0.10	-0.03	-0.04	0.23	-0.21	-0.01	-0.18	0.11	-0.24	0.09	0.32	**1.00**	-0.02	0.18	0.00	-0.35	-0.08	-0.30	-0.15	0.28	0.20	-0.03
P16	-0.13	0.04	0.06	-0.13	-0.11	-0.04	0.05	-0.20	-0.38	-0.15	0.05	-0.28	-0.03	-0.30	-0.02	**1.00**	0.26	-0.15	0.09	0.21	-0.19	0.22	-0.15	-0.35	-0.08
P17	0.35	0.11	-0.06	-0.27	0.03	-0.08	0.02	-0.20	-0.26	-0.15	-0.11	-0.04	-0.07	-0.23	0.18	0.26	**1.00**	-0.05	-0.01	0.08	-0.51	-0.11	0.08	-0.17	0.01
P18	-0.03	-0.12	0.08	0.16	0.14	-0.08	0.28	-0.15	-0.34	-0.08	0.08	-0.08	-0.20	0.28	0.00	-0.15	-0.05	**1.00**	-0.14	-0.25	-0.21	0.04	-0.08	-0.03	-0.03
P19	-0.22	0.06	-0.22	-0.40	-0.06	0.10	0.02	0.17	-0.04	0.20	-0.08	0.17	-0.02	-0.28	-0.35	0.09	-0.01	-0.14	**1.00**	0.12	0.09	0.18	-0.11	0.06	0.01
P20	0.06	0.15	0.07	-0.23	-0.14	-0.26	-0.04	0.13	-0.07	-0.18	-0.15	0.03	0.06	-0.03	-0.08	0.21	0.08	-0.25	0.12	**1.00**	0.06	0.42	-0.18	-0.31	0.35
P21	-0.47	-0.05	0.01	0.25	-0.21	0.07	-0.10	-0.02	0.25	0.40	-0.13	0.10	0.15	0.05	-0.30	-0.19	-0.51	-0.21	0.09	0.06	**1.00**	0.03	0.18	0.08	0.08
P22	-0.17	0.09	0.11	-0.27	0.07	-0.04	0.01	0.01	-0.22	-0.28	0.20	-0.06	0.05	0.01	-0.15	0.22	-0.11	0.04	0.18	0.42	0.03	**1.00**	-0.08	-0.41	-0.14
P23	0.00	0.24	-0.34	-0.04	-0.08	0.11	-0.01	-0.30	0.23	0.21	-0.18	-0.01	0.00	0.08	0.28	-0.15	0.08	-0.08	-0.11	-0.18	0.18	-0.08	**1.00**	0.34	-0.18
P24	-0.07	0.16	-0.22	0.21	0.07	0.24	-0.12	0.08	0.08	0.01	-0.18	0.06	0.30	0.14	0.20	-0.35	-0.17	-0.03	0.06	-0.31	0.08	-0.41	0.34	**1.00**	0.00
P25	-0.05	0.19	-0.10	0.21	0.14	-0.03	-0.10	0.30	0.15	-0.07	-0.07	0.01	0.08	0.20	-0.03	-0.08	0.01	-0.03	0.01	0.35	0.08	-0.14	-0.18	0.00	**1.00**

Brown (1980, p.223) states:

> "*for purposes of rotation, however, [...] it is best to take out more factors than it is expected ahead of time will be significant. Experience has indicated that "the magic number 7" is generally suitable*".

Watts and Stenner (2012, p.197) state:

> "*if you have some priori substantive knowledge of the data you could use this to inform decision. If you don't, start by extracting a factor for every six Q sorts in your study*".

Since using different starting point produce different values for the factor extraction, "*the magic number 7*" has been suggested to be used when the number of participants are more than 36 (see Table A2.1 in Watts and Stenner, 2012, p.197). In this study, I follow Watts and Stenner's suggestion by extracting NF=5 factors ($25/6 \approx 4.17$). This selection can be justified in another way i.e. most of the literature has suggested to consider Var=50% as the minimum acceptable amount. Selection of 5 factors satisfies this criterion (Var=50%). By using the PCA, the first 5 factors for the rotation are kept as shown in Table 3.

Table A-3: All extracted factors (unrotated), 5 first factors are kept for rotation

P \ Factors	**F1**	**F2**	**F3**	**F4**	**F5**	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24	F25
P1	-0.27	0.50	-0.24	-0.22	0.21	-0.23	0.44	0.12	-0.14	0.09	-0.17	-0.18	-0.15	0.17	-0.18	-0.09	-0.19	0.03	-0.03	-0.02	-0.03	0.17	0.00	0.08	-0.05
P2	-0.07	0.21	-0.60	0.40	0.28	0.31	-0.08	0.22	0.11	0.00	-0.02	-0.15	0.08	-0.12	0.16	0.21	0.00	0.15	0.11	-0.08	0.05	0.16	0.08	0.00	0.06
P3	-0.33	-0.04	0.62	-0.01	-0.14	0.03	0.19	-0.23	-0.21	0.29	-0.10	-0.20	0.16	0.17	0.07	0.01	0.26	0.23	0.12	0.09	0.04	0.08	-0.03	-0.05	0.00
P4	0.36	0.34	0.61	-0.14	0.00	0.08	0.21	-0.28	0.27	-0.17	0.03	0.06	-0.20	0.06	-0.19	-0.04	0.05	-0.09	-0.04	-0.05	0.06	0.14	0.11	-0.06	0.07
P5	-0.24	0.15	0.42	0.35	0.18	-0.36	-0.19	0.16	-0.19	-0.16	0.44	0.09	0.12	0.02	-0.17	0.06	-0.13	0.11	-0.01	-0.08	0.20	0.03	-0.04	-0.02	-0.02
P6	0.08	0.22	-0.24	0.69	-0.27	-0.10	0.26	0.14	0.15	-0.03	-0.11	-0.11	0.14	0.08	-0.02	-0.03	0.26	-0.20	-0.19	0.07	0.14	0.02	-0.07	0.03	0.00
P7	-0.33	0.21	0.18	0.00	-0.25	0.32	-0.38	0.10	0.01	0.61	0.09	0.07	0.19	-0.06	-0.08	-0.11	-0.03	-0.12	-0.14	-0.09	-0.02	0.06	0.10	0.02	-0.01
P8	0.06	-0.30	0.51	0.24	0.38	-0.33	-0.04	0.08	0.00	0.08	-0.12	0.32	-0.02	0.19	0.37	0.02	-0.04	-0.06	-0.04	0.04	-0.02	0.07	0.05	0.11	0.02
P9	0.62	0.02	-0.13	-0.15	0.20	-0.02	0.40	0.21	-0.30	0.10	0.08	0.13	0.31	-0.03	-0.20	0.07	0.06	0.09	-0.06	0.14	-0.02	-0.11	0.13	0.04	0.03
P10	0.59	-0.14	-0.17	0.03	-0.37	0.01	0.23	0.04	0.26	0.28	0.23	0.03	-0.29	0.16	0.15	0.20	-0.08	0.14	-0.10	0.02	0.07	0.00	0.03	-0.05	-0.06
P11	-0.30	0.18	0.18	0.38	-0.36	-0.08	0.47	0.27	-0.08	0.09	0.19	0.11	-0.27	-0.20	0.05	-0.14	0.10	0.08	0.10	-0.14	-0.11	-0.09	0.00	0.05	0.04
P12	0.40	-0.40	-0.02	-0.42	0.06	-0.21	-0.26	0.09	-0.22	0.11	0.16	-0.16	-0.25	-0.30	-0.04	0.04	0.26	-0.02	-0.07	0.00	0.05	0.13	-0.05	0.08	0.01
P13	-0.07	0.13	0.19	0.66	0.23	0.01	-0.17	-0.37	-0.13	0.12	0.10	-0.26	-0.22	-0.05	-0.12	0.19	-0.11	-0.02	-0.10	0.16	-0.16	-0.06	0.00	0.02	0.02
P14	0.20	0.47	0.37	-0.17	0.22	0.49	-0.06	0.22	0.05	0.02	-0.10	0.13	-0.05	0.17	-0.12	0.31	0.12	-0.01	0.01	-0.12	-0.04	-0.07	-0.13	0.06	-0.01
P15	-0.15	0.72	-0.17	-0.09	0.20	0.17	-0.01	-0.11	-0.12	0.18	-0.02	0.30	-0.22	-0.20	0.09	-0.06	0.00	-0.06	0.13	0.22	0.17	-0.02	-0.03	-0.02	-0.01
P16	-0.54	-0.25	-0.21	0.01	-0.15	0.15	0.09	-0.44	0.32	-0.15	0.05	0.32	0.07	-0.12	-0.15	0.06	0.08	0.19	-0.09	0.04	0.00	0.06	0.00	0.12	-0.02
P17	-0.47	0.13	-0.42	-0.27	0.16	-0.33	-0.08	-0.18	0.17	0.10	0.29	-0.12	-0.05	0.30	-0.01	0.09	0.20	-0.13	0.14	-0.04	0.04	-0.12	0.09	0.05	0.01
P18	-0.16	0.29	0.32	-0.23	-0.34	0.10	-0.36	0.45	0.28	-0.22	0.02	-0.22	-0.07	0.08	0.04	-0.10	-0.05	0.14	-0.04	0.21	0.02	-0.05	0.04	0.07	0.03
P19	0.05	-0.55	-0.26	0.27	-0.06	-0.15	-0.25	0.26	0.12	0.24	-0.18	0.22	-0.17	0.20	-0.37	-0.05	-0.01	0.05	0.15	0.07	0.00	0.04	-0.04	-0.03	0.04
P20	-0.29	-0.44	-0.08	-0.05	0.56	0.40	0.15	-0.02	-0.03	0.10	-0.02	-0.11	-0.17	0.10	0.03	-0.21	-0.02	0.11	-0.22	-0.07	0.14	-0.13	-0.02	-0.01	0.04
P21	0.61	-0.31	0.14	0.25	-0.12	0.44	0.08	-0.22	-0.02	0.02	0.11	-0.17	0.06	0.04	-0.04	-0.14	-0.14	-0.08	0.25	-0.02	0.11	0.00	0.00	0.13	-0.02
P22	-0.42	-0.39	0.03	0.16	-0.03	0.46	0.01	0.23	-0.38	-0.32	0.02	0.06	-0.21	0.10	-0.05	0.05	0.15	-0.11	0.02	0.05	-0.01	0.05	0.13	-0.03	-0.06
P23	0.37	0.35	-0.44	0.04	-0.07	0.19	-0.22	-0.15	-0.27	-0.12	0.33	0.15	0.03	0.32	0.10	-0.23	0.07	0.08	-0.06	0.02	-0.13	0.09	-0.07	0.00	0.03
P24	0.49	0.39	-0.04	0.33	0.14	-0.22	-0.40	-0.15	-0.01	-0.06	-0.31	0.00	-0.11	-0.03	-0.05	-0.15	0.18	0.18	0.00	-0.12	0.02	-0.09	0.10	0.02	-0.06
P25	0.11	-0.06	0.18	0.10	0.67	0.08	0.12	0.21	0.50	0.05	0.25	-0.05	0.08	-0.10	-0.03	-0.18	0.14	-0.01	0.07	0.08	-0.12	0.05	-0.02	-0.04	-0.06
EV	3.105	2.782	2.629	2.105	1.881	1.648	1.536	1.263	1.147	0.962	0.809	0.737	0.723	0.633	0.556	0.476	0.461	0.339	0.313	0.25	0.211	0.198	0.116	0.084	0.035
Variance% =100*EV/NP	**12.4%**	**11.1%**	**10.5%**	**8.4%**	**7.5%**	**6.6%**	**6.1%**	**5.1%**	**4.6%**	**3.8%**	**3.2%**	**2.9%**	**2.9%**	**2.5%**	**2.2%**	**1.9%**	**1.8%**	**1.4%**	**1.3%**	**1.0%**	**0.8%**	**0.8%**	**0.5%**	**0.3%**	**0.1%**
Comulative Variance	**12.4%**	**23.6%**	**34.1%**	**42.5%**	**50.0%**	**56.6%**	**62.7%**	**67.8%**	**72.4%**	**76.2%**	**79.5%**	**82.4%**	**85.3%**	**87.8%**	**90.1%**	**92.0%**	**93.8%**	**95.2%**	**96.4%**	**97.4%**	**98.3%**	**99.1%**	**99.5%**	**99.9%**	**100%**

Step 3: Factor rotation (Varimax rotation)

The aim of factor rotation in Q methodology is to increase the number of Q sorts which can be loaded to the extracted factors (see the Step 4 for more details about the significant loading). In this study, Varimax rotation function is used. Any rotation function including Varimax rotation can be represented by a matrix which is known as rotation matrix (R). The following equation shows the relationship between unrotated factors, rotated factors and R.

$$\text{rotated factors}_{(25\times5)} = \text{unrotated factors}_{(25\times5)} \times R_{(5\times5)} \qquad \text{Eq. (A-1)}$$

Varimax rotation matrix for this study has been shown in eq. A-2.

$$R = \begin{bmatrix} 0.596 & -0.593 & -0.467 & -0.246 & -0.118 \\ 0.659 & 0.583 & -0.031 & 0.383 & -0.280 \\ 0.409 & -0.308 & 0.768 & 0.098 & 0.372 \\ -0.142 & -0.335 & -0.262 & 0.873 & 0.191 \\ 0.151 & 0.317 & -0.349 & -0.146 & 0.856 \end{bmatrix} \qquad \text{Eq. (A-2)}$$

Determining a Varimax rotation matrix (R) is an iterative optimisation problem. In this problem, we are looking for a square matrix (NF×NF, in this study 5×5). By using Varimax rotation method, our aim is to increase the sum of the variances of the squared correlation between Q sorts and factors (in the rotated factor matrix). However, determining the rotation matrix, R, has some constraints which are related to the mandatory characteristics of orthogonal matrix. It can be proved that the inverse of a rotation matrix R is equal to its transpose as shown in Eq. (A-3).

$$R^{-1} = R^{T} \qquad \text{Eq. (A-3)}$$

This characteristics of rotation matrix brings some other properties as shown in Eq. (A-4) to Eq. (A-6).

$$R \times R^{T} = R \times R^{-1} = identity\ matrix(I) \qquad \text{Eq. (A-4)}$$

[47]

$$Determinant(R) = |R| = 1 \qquad \text{Eq. (A-5)}$$

In this work each column of rotation matrix (R) is called as “a rotation element”. Our example have 5 rotation elements. In a rotation matrix, the length of each rotation element must be 1. For example for the first column of the matrix R:

$$(0.596)^2 + (0.659)^2 + (0.409)^2 + (-0.142)^2 + (0.151)^2 = 1 \qquad \text{Eq. (A-6)}$$

This is a mandatory requirement for each element of the rotation matrix. Every row in a matrix of unrotated factors (loading of Q sort on each unrotated factor) is multiplied by these elements to determine the new loading of that Q sort on the

[47] Identity matrix is a square matrix which has one on the main diagonal and zeros elsewhere.

rotated coordinate system. Although by applying the factor rotation the direction (or angles) of the unrotated factors with respect to a fix coordinate system will be changed, but the “length” or in a better word the importance of a participant’s attitude should not change. Similarly it can be shown that sum of squared of each row is 1, for example:

$$(0.596)^2 + (-0.593)^2 + (-0.467)^2 + (-0.246)^2 + (-0.118)^2 = 1 \qquad \text{Eq. (A-7)}$$

In order to prove this, if we multiple R^{-1} to both sides of Eq. (A-1), we would have:

$$\text{rotated factors} \times R^{-1} = \text{unrotated factors} \times R \times R^{-1} = \text{unrotated factors} \qquad \text{Eq. (A-8)}$$

By using Eq. (A-3) we can change Eq. (A-8) to the following equation:

$$\text{rotated factors} \times R^{T} = \text{unrotated factors} \qquad \text{Eq. (A-9)}$$

Hence, matrix R^T is also a rotation matrix which can be used to convert rotated factors to unrotated ones. As a result, each column of matrix R^T (transpose of the matrix R) must also have a length of 1, or in other words each row of the matrix R must have a length of 1. Considering the number of unknown elements in a rotation matrix (in our example 25 unknown number), and the mandatory requirements of a rotation matrix, it can be concluded that the number of unknown elements is more than the number of equations. As a result, there are as expected indefinite number of solutions (rotation matrixes), but what Varimax rotation is looking for is to choose one of these rotation matrixes which can maximise the sum of the variances of the squared correlation (SVSC) between Q sorts and factors (in the new coordinate system or the rotated factor matrix).

Table A-4 and Table A-5 show unrotated and rotated factors respectively in our example, and compare the SVSC for each of them. It can be concluded that by applying Varimax rotation, the SVSC value has increased from 0.334 (for unrotated factors) to the maximum possible amount 0.473 (for rotated factors).

As shown in these tables, although the eigenvalues of rotated factors (and consequently the explained variance by each factor) are different from those of the unrotated factors, the total variance of the study explained by the rotated set of factors are the same as that of unrotated factors, i.e. Var (rotated)=Var (unrotated)= 50%. Researchers, therefore, will not ignore any data in factor rotation phase. Furthermore, the sum of squared loadings for each participant is the same figure in both tables. Hence, the total opinion of any participant known as communality has not been changed.

Table A-4: Unrotated factors

P \ Factors	F1	F2	F3	F4	F5	$F1^2$	$F2^2$	$F3^2$	$F4^2$	$F5^2$	∑Fi2	Variance(Fi^2)
P1	-0.269	0.500	-0.240	-0.222	0.214	0.072	0.250	0.057	0.049	0.046	0.476	0.006
P2	-0.073	0.211	-0.600	0.399	0.281	0.005	0.044	0.360	0.159	0.079	0.648	0.016
P3	-0.329	-0.040	0.622	-0.011	-0.139	0.108	0.002	0.386	0.000	0.019	0.516	0.022
P4	0.364	0.342	0.606	-0.137	-0.002	0.132	0.117	0.367	0.019	0.000	0.635	0.017
P5	-0.239	0.153	0.425	0.354	0.184	0.057	0.023	0.180	0.125	0.034	0.420	0.004
P6	0.078	0.219	-0.240	0.689	-0.265	0.006	0.048	0.058	0.475	0.070	0.657	0.030
P7	-0.329	0.207	0.178	0.002	-0.247	0.108	0.043	0.032	0.000	0.061	0.244	0.001
P8	0.059	-0.299	0.506	0.241	0.384	0.003	0.090	0.256	0.058	0.147	0.555	0.007
P9	0.620	0.024	-0.129	-0.145	0.202	0.384	0.001	0.017	0.021	0.041	0.463	0.021
P10	0.588	-0.136	-0.171	0.030	-0.365	0.346	0.018	0.029	0.001	0.133	0.528	0.017
P11	-0.304	0.180	0.184	0.380	-0.359	0.092	0.032	0.034	0.144	0.129	0.432	0.002
P12	0.403	-0.402	-0.021	-0.421	0.062	0.163	0.162	0.000	0.177	0.004	0.506	0.007
P13	-0.070	0.131	0.191	0.657	0.229	0.005	0.017	0.036	0.432	0.053	0.543	0.026
P14	0.202	0.467	0.374	-0.169	0.219	0.041	0.218	0.140	0.028	0.048	0.475	0.005
P15	-0.148	0.717	-0.174	-0.092	0.202	0.022	0.514	0.030	0.009	0.041	0.616	0.038
P16	-0.541	-0.254	-0.213	0.006	-0.148	0.293	0.064	0.045	0.000	0.022	0.425	0.011
P17	-0.470	0.131	-0.418	-0.268	0.156	0.221	0.017	0.175	0.072	0.024	0.509	0.007
P18	-0.165	0.285	0.324	-0.230	-0.340	0.027	0.081	0.105	0.053	0.116	0.382	0.001
P19	0.046	-0.555	-0.255	0.268	-0.055	0.002	0.308	0.065	0.072	0.003	0.450	0.013
P20	-0.287	-0.445	-0.077	-0.053	0.562	0.082	0.198	0.006	0.003	0.316	0.605	0.015
P21	0.611	-0.312	0.144	0.248	-0.125	0.374	0.097	0.021	0.061	0.016	0.568	0.018
P22	-0.421	-0.392	0.030	0.165	-0.028	0.177	0.154	0.001	0.027	0.001	0.360	0.006
P23	0.368	0.353	-0.438	0.043	-0.072	0.135	0.125	0.192	0.002	0.005	0.459	0.006
P24	0.485	0.394	-0.043	0.328	0.143	0.236	0.155	0.002	0.108	0.020	0.521	0.007
P25	0.111	-0.059	0.182	0.101	0.673	0.012	0.003	0.033	0.010	0.453	0.512	0.031
EV	**3.105**	**2.782**	**2.629**	**2.105**	**1.881**						**SVSC=**	**0.334**
Variance% =100*EV/NP	12.4%	11.1%	10.5%	8.4%	7.5%							
Comulative Variance	12.4%	23.6%	34.1%	42.5%	50.0%							

Table A-5: Rotated factors

P \ Factors	F1	F2	F3	F4	F5	$F1^2$	$F2^2$	$F3^2$	$F4^2$	$F5^2$	∑Fi2	Variance(Fi^2)
P1	0.135	**0.668**	-0.090	0.009	-0.056	0.018	0.446	0.008	0.000	0.003	0.476	0.031
P2	-0.164	0.307	**-0.636**	0.347	0.043	0.027	0.094	0.405	0.121	0.002	0.648	0.021
P3	0.013	-0.059	**0.684**	0.137	0.160	0.000	0.004	0.468	0.019	0.025	0.516	0.033
P4	**0.709**	-0.158	0.322	-0.018	0.059	0.503	0.025	0.104	0.000	0.003	0.635	0.037
P5	0.110	0.040	0.276	**0.441**	0.368	0.012	0.002	0.076	0.195	0.136	0.420	0.005
P6	-0.046	-0.160	-0.316	**0.681**	-0.255	0.002	0.026	0.100	0.464	0.065	0.657	0.029
P7	-0.024	0.182	0.370	0.215	-0.164	0.001	0.033	0.137	0.046	0.027	0.244	0.002
P8	0.068	-0.324	0.173	0.075	**0.640**	0.005	0.105	0.030	0.006	0.409	0.555	0.024
P9	0.384	-0.201	-0.422	-0.312	0.017	0.147	0.041	0.178	0.097	0.000	0.463	0.004
P10	0.131	**-0.501**	-0.283	-0.133	-0.402	0.017	0.251	0.080	0.018	0.162	0.528	0.008
P11	-0.096	-0.013	0.304	**0.545**	-0.181	0.009	0.000	0.092	0.297	0.033	0.432	0.012
P12	0.036	-0.306	-0.104	**-0.632**	0.030	0.001	0.094	0.011	0.399	0.001	0.506	0.023
P13	0.064	-0.089	-0.077	**0.626**	0.364	0.004	0.008	0.006	0.392	0.133	0.543	0.023
P14	**0.638**	0.163	0.146	-0.013	0.140	0.407	0.027	0.021	0.000	0.020	0.475	0.024
P15	0.357	**0.654**	-0.133	0.184	-0.092	0.127	0.428	0.018	0.034	0.008	0.616	0.025
P16	**-0.600**	0.190	0.147	0.042	-0.070	0.360	0.036	0.022	0.002	0.005	0.425	0.019
P17	-0.304	**0.623**	-0.090	-0.132	-0.054	0.092	0.389	0.008	0.017	0.003	0.509	0.022
P18	0.204	0.133	**0.496**	0.031	-0.275	0.041	0.018	0.246	0.001	0.076	0.382	0.008
P19	**-0.489**	-0.380	-0.252	-0.007	0.059	0.239	0.144	0.063	0.000	0.003	0.450	0.008
P20	-0.403	0.131	-0.094	-0.236	**0.601**	0.163	0.017	0.009	0.056	0.361	0.605	0.017
P21	0.164	**-0.711**	-0.187	-0.021	0.009	0.027	0.506	0.035	0.000	0.000	0.568	0.039
P22	**-0.525**	-0.052	0.198	0.104	0.178	0.275	0.003	0.039	0.011	0.032	0.360	0.011
P23	0.256	0.085	**-0.505**	0.050	-0.358	0.065	0.007	0.255	0.003	0.128	0.459	0.009
P24	**0.506**	-0.110	-0.407	0.293	0.002	0.257	0.012	0.166	0.086	0.000	0.521	0.009
P25	0.189	0.024	-0.171	-0.042	**0.667**	0.036	0.001	0.029	0.002	0.445	0.512	0.030
EV	**2.837**	**2.715**	**2.606**	**2.265**	**2.080**						**SVSC=**	**0.473**
Variance% =100*EV/NP	11.3%	10.9%	10.4%	9.1%	8.3%							
Comulative Variance	11.3%	22.2%	32.6%	41.7%	50.0%							

Step 4: finding the important factors and significant Q sorts for each factor (flagging)

Different scholars have made different suggestions about the selection of important factors and significant Q sorts (Kampen and Tamás, 2013). In this study, the rules mentioned by Brown (1980) and Watts and Stenner (2012) have been used. Brown (1980, p.222) states:

> *"Perhaps the most widely used method to determine the number of factors is to extract the number which have eigenvalues in excess of 1.00. … Another method for determining the number of factors is to accept those that have at least two significant loadings. … For a loading to be significant at the 0.01 level, it must exceed 2.58(SE_r). … At the 0.05 level, loadings exceeding 1.96(SE_r) […] are significant. Humphrey's rule … states that a factor is*

significant if the cross-product of its two highest loadings (ignoring sign) exceeds twice the standard error, i.e., 2(SE$_r$). ... A less stringent use of Humphrey's rule is to insist that the cross-products exceed at least I(SEr)".

In this example, SE$_r$ has been calculated in Eq. (A-10).

$$SE_r = \frac{1}{\sqrt{NS}} = \frac{1}{\sqrt{36}} = 0.167 \longrightarrow 2SE_r = 0.333 \qquad \text{Eq. (A-10)}$$

We can calculate the Significant Loading Coefficient (SLC) at 0.01 level as given in Eq. (A-11).

$$SLC = 2.58 \times SE_r = \frac{2.58}{\sqrt{NS}} = \frac{2.58}{\sqrt{36}} = 0.43 \qquad \text{Eq. (A-11)}$$

The next step is grouping the participants known as flagging. The aim of flagging (or factor exemplifying) is to find the Q sorts which have been loaded significantly on different factors. Donner (2001b, p.32) states "*this is the step at which you are creating the subgroups and establishing the foundation for the calculation of the distinct "voices" present among your participants*". In Table A-5 (rotated factors), **bold** figures are indicative of factor loadings of 0.43 or above (ignoring sign). As can be seen in this table, except P7 and P9, all other Q sorts have been loaded significantly at least on one of the rotated factors. There is no *confounded* sort, i.e. none of these sorts has significant factor loading on more than one of the rotated factors. Following the Watt and Stenner's example (Watts and Stenner, 2012, p.130), in other examples (and samples) of this paper we do not use confounded sorts in estimating the factors. Table A-6 summarises the Q sorts which have been loaded significantly on different factors.

Table A-6- factor exemplifying

F1 ○	F2 △	F3 ◇	F4 ▭	F5 ≫	not loaded	confounded
P4	P1	P2	P5	P8	P7	
P14	P10	P3	P6	P20	P9	
P16	P15	P18	P11	P25		
P19	P17	P23	P12			
P22	P21		P13			
P24						

Step 5: Calculation of factor weights

Table A-7- factor weights

Factor 1				Factor 2			
Examlifier	Factor Loading (FL)	Initial Weight, IW=FL/(1-FL^2)	Reciprocal =IW/max(IW)	Examlifier	Factor Loading (FL)	Initial Weight, IW=FL/(1-FL^2)	Reciprocal =IW/max(IW)
P4	0.709	1.427	1.000	P1	0.668	1.205	0.837
P14	0.638	1.077	0.754	P10	-0.501	-0.669	-0.465
P16	-0.600	-0.938	-0.657	P15	0.654	1.144	0.795
P19	-0.489	-0.642	-0.450	P17	0.623	1.019	0.708
P22	-0.525	-0.724	-0.507	P21	-0.711	-1.440	-1.000
P24	0.506	0.681	0.477				
		max(IW)=1.427				max(IW)=1.205	

Factor 3				Factor 4			
Examlifier	FL	IW	IW/max(IW)	Examlifier	FL	IW	IW/max(IW)
P2	-0.636	-1.068	-0.831	P5	0.441	0.548	0.431
P3	0.684	1.286	1.000	P6	0.681	1.271	1.000
P18	0.496	0.658	0.512	P11	0.545	0.776	0.610
P23	-0.505	-0.679	-0.528	P12	-0.632	-1.050	-0.826
				P13	0.626	1.030	0.810
		max(IW)=1.286				max(IW)=1.271	

Factor 5			
Examlifier	FL	IW	IW/max(IW)
P8	0.640	1.083	0.901
P20	0.601	0.940	0.782
P25	0.667	1.202	1.000
		max(IW)=1.202	

Step 6: Estimating the factors

In Table A-8, estimation of factor A has been shown. The process is similar for other factors.

Table A-8- Factor estimation for F1/SSS1 in example 1

Examlifier	P4		P14		P16		P19		P22		P24		K= ∑RW×Sort	Z Scores =(K-AVE)/STD	Sorting for Factor 1
Reciprocal Weight (RW)	1.000		0.754		-0.657		-0.450		-0.507		0.477				
	Sort	RW× Sort	Sort	RW× Sort	Sort	RW× Sort	Sort	RW× Sort	Sort	RW× Sort	Sort	RW× Sort			
S1	1	1.00	1	0.75	-3	1.97	-2	0.90	0	0.00	3	1.43	6.06	1.46	3
S2	0	0.00	0	0.00	0	0.00	-1	0.45	-3	1.52	0	0.00	1.97	0.48	1
S3	-3	-3.00	0	0.00	-1	0.66	1	-0.45	2	-1.01	-2	-0.95	-4.76	-1.15	-2
S4	2	2.00	2	1.51	1	-0.66	-1	0.45	3	-1.52	-3	-1.43	0.35	0.08	0
S5	0	0.00	-2	-1.51	-1	0.66	-3	1.35	0	0.00	0	0.00	0.50	0.12	0
S6	3	3.00	2	1.51	0	0.00	-2	0.90	-3	1.52	3	1.43	8.36	2.02	3
S7	0	0.00	-3	-2.26	2	-1.31	2	-0.90	1	-0.51	0	0.00	-4.98	-1.20	-2
S8	-1	-1.00	1	0.75	-2	1.31	2	-0.90	-1	0.51	3	1.43	2.11	0.51	1
S9	-2	-2.00	0	0.00	1	-0.66	0	0.00	1	-0.51	2	0.95	-2.21	-0.53	-1
S10	1	1.00	-1	-0.75	-1	0.66	2	-0.90	-3	1.52	0	0.00	1.52	0.37	0
S11	0	0.00	2	1.51	-2	1.31	-1	0.45	-1	0.51	1	0.48	4.26	1.03	2
S12	0	0.00	-2	-1.51	3	-1.97	0	0.00	0	0.00	-1	-0.48	-3.96	-0.96	-2
S13	-1	-1.00	-2	-1.51	-1	0.66	2	-0.90	1	-0.51	0	0.00	-3.26	-0.79	-1
S14	-1	-1.00	2	1.51	0	0.00	-3	1.35	-1	0.51	-1	-0.48	1.89	0.46	1
S15	-1	-1.00	-2	-1.51	1	-0.66	-2	0.90	-2	1.01	-1	-0.48	-1.73	-0.42	-1
S16	-3	-3.00	-1	-0.75	3	-1.97	0	0.00	0	0.00	-3	-1.43	-7.16	-1.73	-3
S17	-3	-3.00	-3	-2.26	2	-1.31	3	-1.35	2	-1.01	1	0.48	-8.46	-2.04	-3
S18	-1	-1.00	0	0.00	-3	1.97	1	-0.45	1	-0.51	1	0.48	0.49	0.12	0
S19	1	1.00	1	0.75	0	0.00	-3	1.35	2	-1.01	-1	-0.48	1.61	0.39	0
S20	1	1.00	2	1.51	0	0.00	3	-1.35	-1	0.51	0	0.00	1.67	0.40	1
S21	0	0.00	-1	-0.75	2	-1.31	0	0.00	2	-1.01	-1	-0.48	-3.56	-0.86	-2
S22	1	1.00	1	0.75	-1	0.66	1	-0.45	0	0.00	0	0.00	1.96	0.47	1
S23	1	1.00	-3	-2.26	2	-1.31	-1	0.45	-2	1.01	2	0.95	-0.16	-0.04	0
S24	3	3.00	3	2.26	1	-0.66	-2	0.90	3	-1.52	-2	-0.95	3.03	0.73	2
S25	3	3.00	3	2.26	-2	1.31	0	0.00	-2	1.01	2	0.95	8.55	2.06	3
S26	-1	-1.00	0	0.00	3	-1.97	2	-0.90	1	-0.51	-3	-1.43	-5.81	-1.40	-2
S27	-2	-2.00	-2	-1.51	0	0.00	1	-0.45	-1	0.51	0	0.00	-3.45	-0.83	-1
S28	2	2.00	-1	-0.75	1	-0.66	-1	0.45	0	0.00	-2	-0.95	0.08	0.02	0
S29	0	0.00	0	0.00	-1	0.66	1	-0.45	0	0.00	1	0.48	0.68	0.17	0
S30	2	2.00	-1	-0.75	-3	1.97	0	0.00	-2	1.01	1	0.48	4.71	1.14	2
S31	0	0.00	0	0.00	-2	1.31	-2	0.90	-2	1.01	-2	-0.95	2.27	0.55	1
S32	2	2.00	1	0.75	2	-1.31	0	0.00	-1	0.51	1	0.48	2.42	0.59	2
S33	2	2.00	3	2.26	0	0.00	-1	0.45	1	-0.51	2	0.95	5.16	1.25	2
S34	-2	-2.00	1	0.75	1	-0.66	1	-0.45	0	0.00	2	0.95	-1.40	-0.34	-1
S35	-2	-2.00	0	0.00	-2	1.31	0	0.00	2	-1.01	-2	-0.95	-2.65	-0.64	-1
S36	-2	-2.00	-1	-0.75	0	0.00	3	-1.35	3	-1.52	-1	-0.48	-6.10	-1.47	-3
												Sum:	0.00		
												Std. Dev. :	4.14		
												Mean:	0.00		

Appendix A-2: Ethical Approval

UNIVERSITY OF ULSTER **RESEARCH GOVERNANCE**

RG3 Filter Committee Report Form

Project Title	The Implementation of Climate Change Adaptation Policies to Increase the Resilience of Road Transport Sector
Chief Investigator	Prof. Julian Hine (Eghbalighazijahani/Hine/Kashyap)
Filter Committee	FADBE RGFC

This form should be completed by Filter Committees for all research project applications in categories A to D (*for categories A, B, and D the University's own application form – RG1a and RG1b – will have been submitted; for category C, the national, or ORECNI, application form will have been submitted).

Where substantial changes are required the Filter Committee should return an application to the Chief Investigator for clarification/amendment; the Filter Committee can reject an application if it is thought to be unethical, inappropriate, incomplete or not valid/viable.

Only when satisfied that its requirements have been met in full and any amendments are complete, the Filter Committee should make one of the following recommendations:

The research proposal is complete, of an appropriate standard and is in

- category A and the study may proceed* [X]
- category B and the study must be submitted to the University's Research Ethics Committee** Please indicate briefly the reason(s) for this categorisation [ ]
- category C and the study must be submitted to ORECNI along with the necessary supporting materials from the Research Governance Section*** [ ]
- category D and the study must be submitted to the University's Research Ethics Committee** [ ]

Signed: Date: 23rd of May 2013
Chairperson/Administrator of Filter Committee

***The application form and this assessment should now be returned to the Chief Investigator. The Filter Committee should retain a copy of the complete set of forms.**

**** The application form and this assessment should now be returned to the Chief Investigator so that he/she can submit the application to the UUREC via the Research Governance section. The Filter Committee should retain a copy of the complete set of forms for their own records.**

***** The application form and this assessment should now be returned to the Chief Investigator so that he/she can prepare for application to a NRES/ORECNI committee. The Filter Committee should retain a copy of the complete set of forms for their own records.**

<u>For all categories, details of the application and review outcome should be minuted using the agreed format and forwarded to the Research Governance section</u>

Version 3 (10/07) 1

Please complete the following

The application should be accompanied by an appropriate and favourable Peer Review Report Form (if not, the Filter Committee should be prepared to address this as part of its review). Please comment on the peer review (include whether or not there is evidence that the comments of the peer reviewers have been addressed).

The application was accompanied by an appropriate and favourable peer review report.

Please provide an assessment of all component parts of the application, including questionnaires, interview schedules or outline areas for group discussion/unstructured interviews.

All component parts of the application are appropriate and well designed.

Please comment on the consent form and information sheet, in particular the level of language and accessibility.

The consent form and information sheet are designed in an appropriate level of language and are accessible.

Please comment on the qualifications of the Chief and other Investigators.

Excellent

Please comment on the risks present in conducting the study and whether or not they have been addressed.

Risks have been considered and are managed.

Please indicate whether or not the ethical issues have been identified and addressed.

Ethical issues have been identified and addressed.

Please comment on whether or not the subjects are appropriate to the study and the inclusion/exclusion criteria have been identified and listed

Subjects are appropriate to the study and the inclusion/exclusion criteria have been identified and listed.

Appendix A-3:Subject Information Sheet

INFORMATION SHEET

The Implementation of Climate Change Adaptation Policies to Increase the Resilience of Road Transport Sector

Hello. My name is Amir Eghbalighazijahani and I am a PhD student at University of Ulster Jordanstown campus under supervision of Prof. Julian Hine, Dr Lisa Davison and Dr Lesley Hemphill. I would like to thank you for taking part in this research which aims to examine the relationship between transport governance arrangements at the city level and the implementation of climate change adaptation policies. Before you take part in this study, I requested you to please read the following sections sheet to get brief introduction about the research. If you need any clarification or have ambiguities about any part of the information sheet, please feel free to ask. It is very important that you are happy with your decision to participate in the study. Your comments and feedback is highly valuable for our research and will be kept confidential. We hope that you will feel free to speak openly about your real experiences and perceptions about the research topic.

The Research

Climate change has become a serious global challenge. This study is concerned with the implementation of climate change adaptation policies and integration of these policies into transport policies in the UK. The focus of the research is on the road transport sector.

Scientists have reported the necessity of climate change adaptation to address the unavoidable impacts of climate change. The UK Government introduced the Climate Change Act (2008) and became obligated to develop and implement appropriate adaptation programmes. Climate change risk assessments show that the transport sector in the UK is at the risk of the excess winter rainfall, flooding, high summer temperature and landslides.

These impacts not only can harm the transport infrastructure, but they can also impose further cost to the system by changing the speed, route and mode. Literature shows that travelling through congested areas under adverse weather condition reduces the speed of traffic flow. Some predictions argue that this impact have the potential to double the delays and lost trips. The modal shift is another impact of the climate change on road transport sector which may cause infrastructure disruptions and can negatively affect the sustainable transport. For example, the climate where one lives is an influential factor in deciding to use the bicycle. According to literature, more precipitation and lower temperature can associate with lower levels of cycling. A recent study in Netherland show that most of cyclists use individual cars in precipitation condition As the result, although increasing in the temperature during the summer times can be a motivator for the UK's people to use cycling, increasing the precipitation during the winter is an obstacle that may cause a modal shift from green modes of transport such as walking and cycling to other modes..

Most of the above mentioned impacts can harm the sustainable transport. However, the main focus of research and policies in the transport sector in climate change context is on the mitigation of greenhouse gas emissions; and action on climate adaptation has remained marginal and is usually a secondary impact of policies designed to tackle other urban problems.

In UK, the road transport governance arrangement has a multi-level polity system. Responsibilities for achieving the aims and objectives of the policies are shared between different organisations at different levels. Hence, climate change policies and strategies are made and implemented across multiple spatial levels with large number of actors. Governing the urban areas like Cambridge is a huge challenge in terms of provision for transparency of decision-making processes, the equitable distribution of power between existing transport structures, the vertical and horizontal coordination of transport policies and executing effective implementation of transport programmes with limited financial resources. As the result, decision making about and implementation of adaptation policies is a complex process, mainly because of existing the multitude actors at different levels, their interdependencies and varying interests and powers.

This study seeks to examine the challenges faced by different stakeholders during the decision making and implementation of climate change adaptation policies. We aim to assess the impacts of different city region transport governance models on the implementation of climate change adaptation policies. In doing so, we investigate how effectively these policies are implemented by the existing transport authorities at the city level and what are the main obstacles faced by them in the delivery of climate change policy decisions.

Appendix A-4: In-depth Interview Questions

1. Transport sector and climate change challenge

a) What are the key climate change challenges facing Cambridge's road transport sector?

b) What are the possible measures for adaptation? What are the main barriers in decision making and implementation of climate change adaptation policies?

2. Adequacy of policy measures

a) What policies are currently in place which support climate change adaptation in transport sector? How effective are these policies?

b) Do you think current policies are adequate to adapt transport sector to future climatic changes? Are there any gaps? What other policy measures should be considered?

c) How should climate change adaptation policies be prioritised?

3. Governance

a) Who are the key stakeholders involved in translating climate change adaptation objectives into local transport initiatives and actions? How do different stakeholders manage their working relationships?

b) How effective are the existing transport governance arrangements in decision making of transport policies and projects?

c) How effective are the existing governance arrangements in transport planning process?

d) How effective are the existing transport governance arrangements in the implementation and delivery of transport policies and proposals?

e) What changes are required in power distribution between bodies to improve the delivery of climate change adaptation policies?

4. Transparency, accountability and participation

a) How do interest groups involve/impact the process of policy implementation (decision making/monitoring/evaluation)?

b) How do the transport organisations respond to potential climate change impacts? (capacity/knowledge on climate change/uncertainty/ climate change scenarios)

c) Is the current transport governance model accountable? What changes are needed?

d) Is the policy implementation process transparent? What changes are needed?

5. Funding mechanism

a) What are the primary funding sources for transport projects in Cambridge?

b) Are there enough investments in road transport sector to adapt to climate change impacts? Should more financial incentives be made available?

c) How important is the role of politicians in the prioritisation of transport projects?

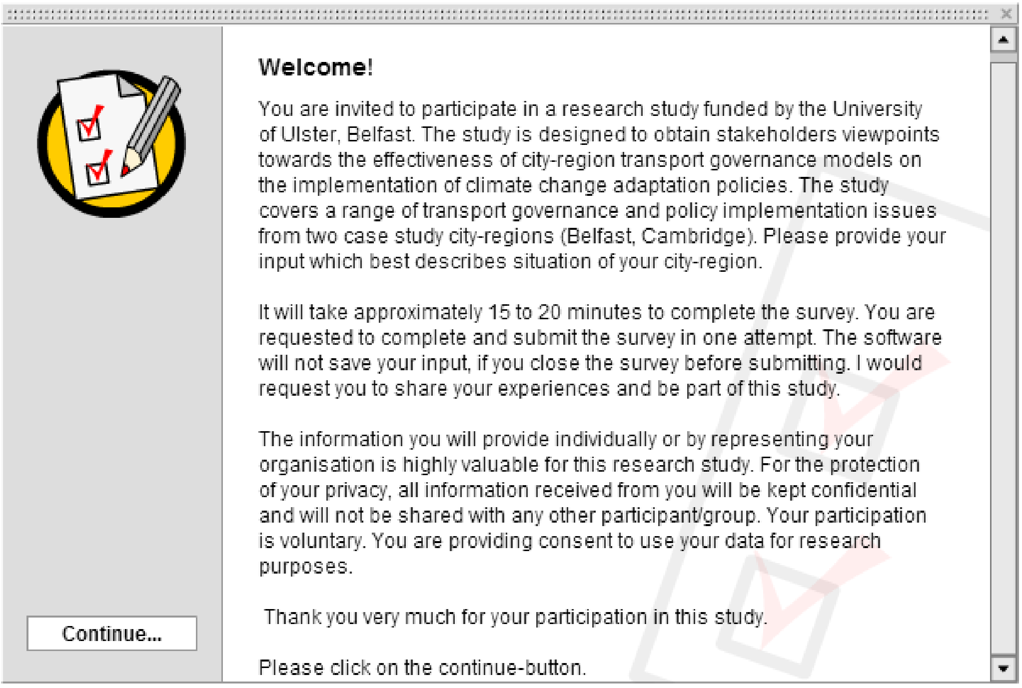
d) Does the funding regime help road transport sector to adapt to climate change? What changes are needed?

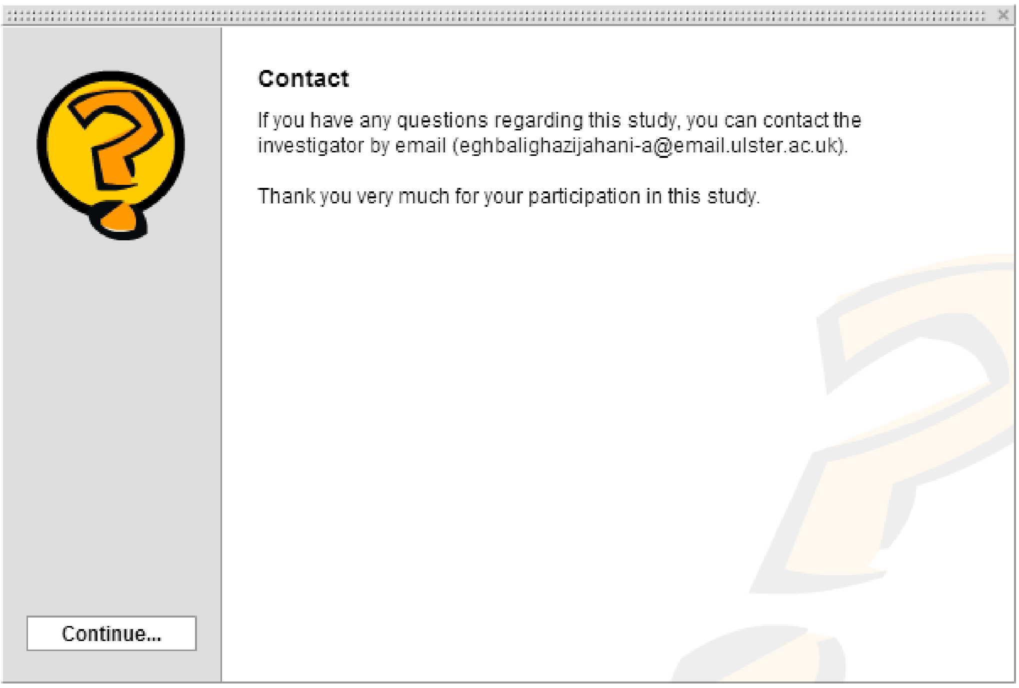
6. Suggestions

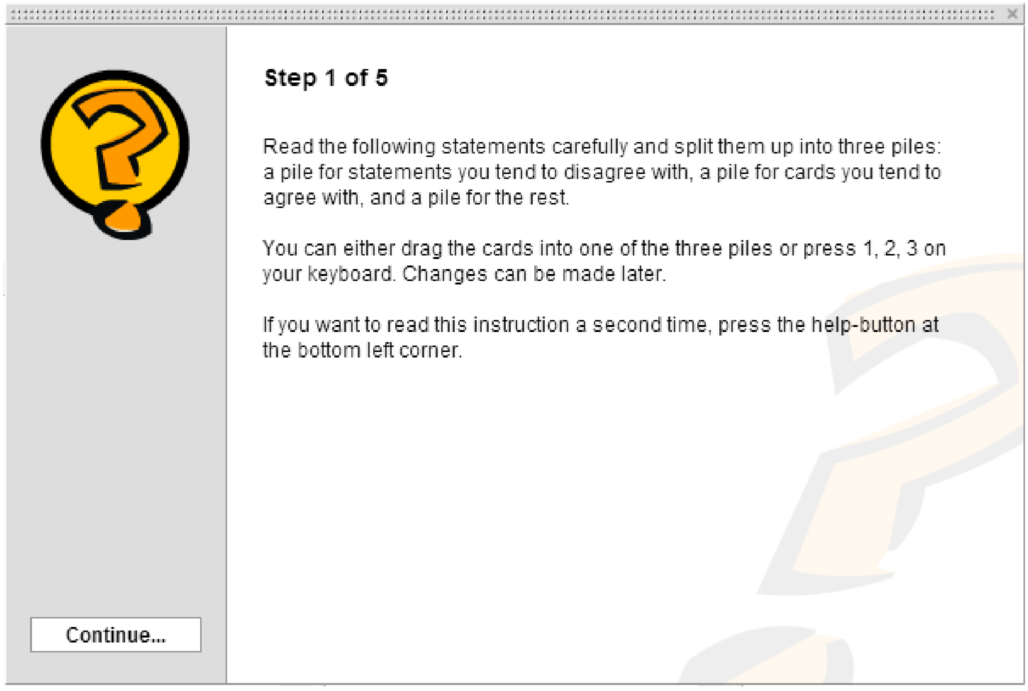
What are your suggestions regarding the improvement of transport governance in delivery of climate change policies?

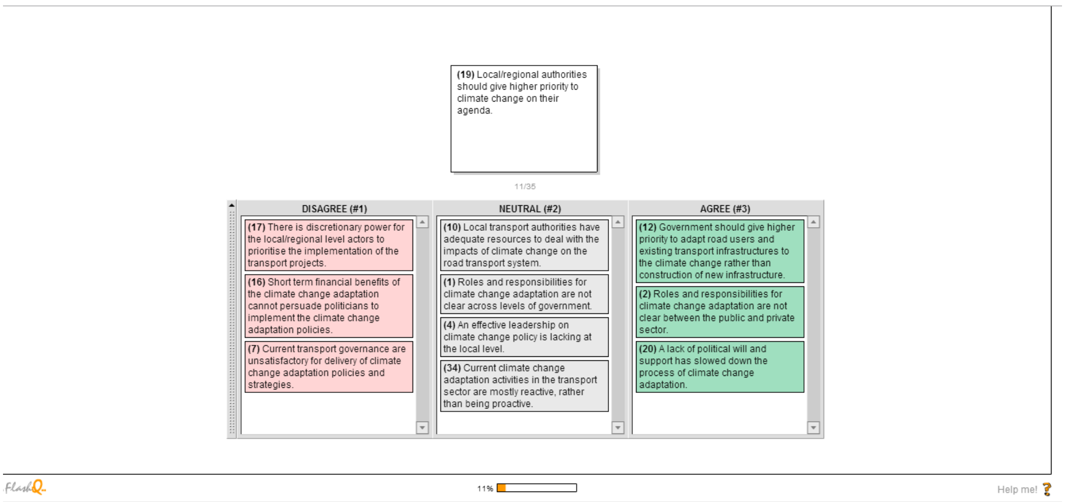
Appendix A-5: Online Q Survey (FlashQ)

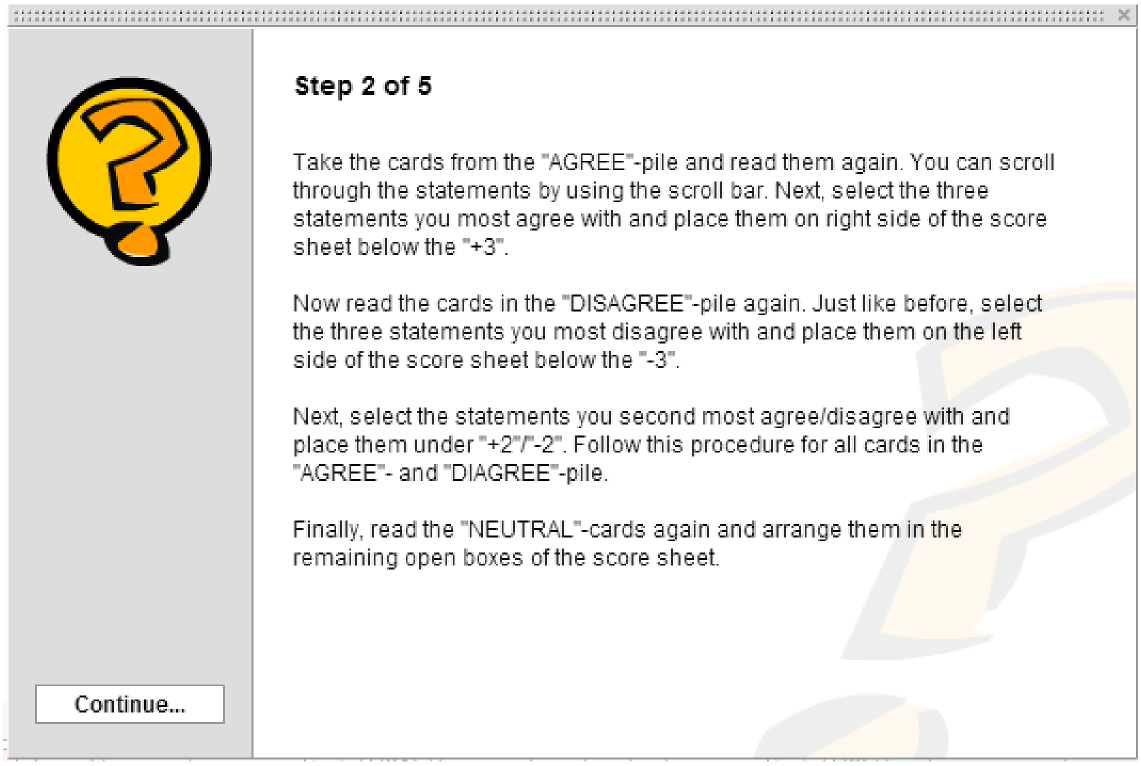
The survey is available on http://www.resilient-transport.tk/ website.

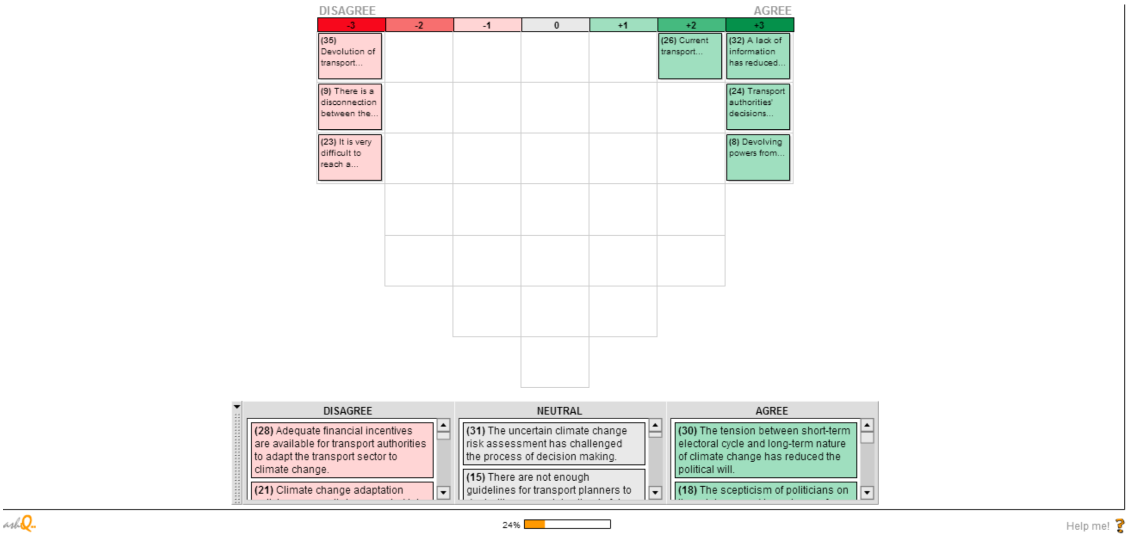


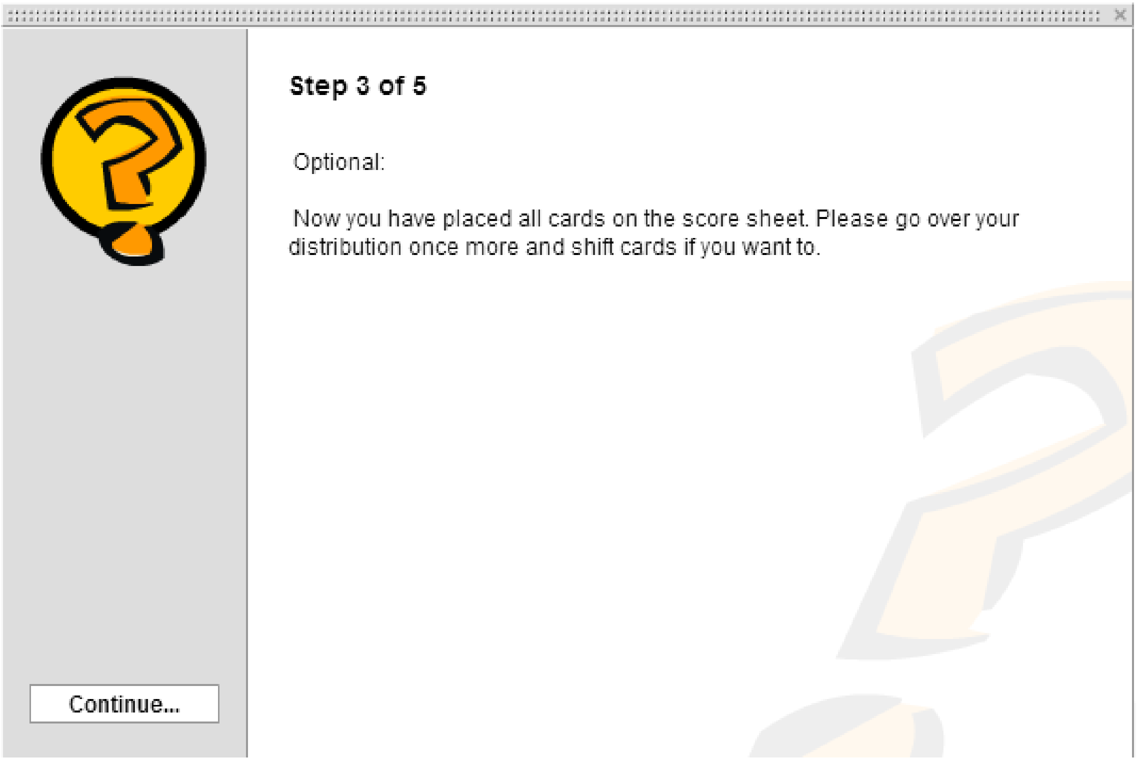



Step 1 of 5
Read the following statements carefully and split them up into three piles: a pile for statements you tend to disagree with, a pile for cards you tend to agree with, and a pile for the rest.
You can either drag the cards into one of the three piles or press 1, 2, 3 on your keyboard. Changes can be made later.
If you want to read this instruction a second time, press the help-button at the bottom left corner.
Continue...


(19) Local/regional authorities should give higher priority to climate change on their agenda.
11/35
DISAGREE (#1)
(17) There is discretionary power for the local/regional level actors to prioritise the implementation of the transport projects.
(16) Short term financial benefits of the climate change adaptation cannot persuade politicians to implement the climate change adaptation policies.
(7) Current transport governance are unsatisfactory for delivery of climate change adaptation policies and strategies.
NEUTRAL (#2)
(10) Local transport authorities have adequate resources to deal with the impacts of climate change on the road transport system.
(1) Roles and responsibilities for climate change adaptation are not clear across levels of government.
(4) An effective leadership on climate change policy is lacking at the local level.
(34) Current climate change adaptation activities in the transport sector are mostly reactive, rather than being proactive.
AGREE (#3)
(12) Government should give higher priority to adapt road users and existing transport infrastructures to the climate change rather than construction of new infrastructure.
(2) Roles and responsibilities for climate change adaptation are not clear between the public and private sector.
(20) A lack of political will and support has slowed down the process of climate change adaptation.
11%
Help me!


Step 2 of 5
Take the cards from the "AGREE"-pile and read them again. You can scroll through the statements by using the scroll bar. Next, select the three statements you most agree with and place them on right side of the score sheet below the "+3".
Now read the cards in the "DISAGREE"-pile again. Just like before, select the three statements you most disagree with and place them on the left side of the score sheet below the "-3".
Next, select the statements you second most agree/disagree with and place them under "+2"/"-2". Follow this procedure for all cards in the "AGREE"- and "DIAGREE"-pile.
Finally, read the "NEUTRAL"-cards again and arrange them in the remaining open boxes of the score sheet.
Continue...


DISAGREE
AGREE
-3
-2
-1
0
+1
+2
+3
(35) Devolution of transport...
(9) There is a disconnection between the...
(23) It is very difficult to reach a...
(26) Current transport...
(32) A lack of information has reduced...
(24) Transport authorities' decisions...
(8) Devolving powers from...
DISAGREE
NEUTRAL
AGREE
(28) Adequate financial incentives are available for transport authorities to adapt the transport sector to climate change.
(21) Climate change adaptation
(31) The uncertain climate change risk assessment has challenged the process of decision making.
(15) There are not enough guidelines for transport planners to
(30) The tension between short-term electoral cycle and long-term nature of climate change has reduced the political will.
(18) The scepticism of politicians on
24%
Help me!


Step 3 of 5
Optional:
Now you have placed all cards on the score sheet. Please go over your distribution once more and shift cards if you want to.
Continue...

Step 4 of 5

Optional:

Please explain why you agree most or disagree most with the following statements you have placed below "+3" or "-3".

Continue...

Agree (+3)

(8) Devolving powers from national/regional level to local level can...

(24) Transport authorities' decisions are more consistent with the...

(32) A lack of information has reduced the transparency of the decision...

Disagree (-3)

(9) There is a disconnection between the current national funding...

(23) It is very difficult to reach a consensus among different transport...

(35) Devolution of transport powers, from the national/regional level to the...

Name, gender and e-mail

Name: *

Gender: *

female

male

Email: *

Group and city

Your group: *

Local public organisation

National/regional public organisation

NGO

Academic

Expert/user/interest group

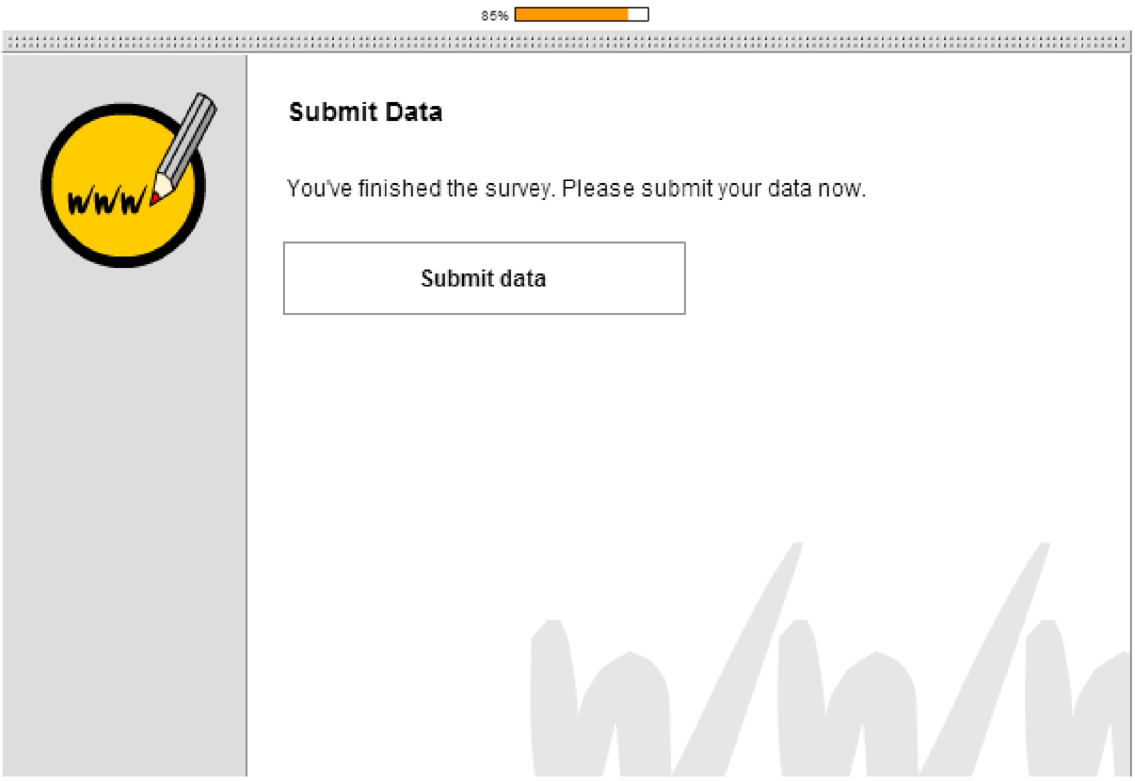
Other

City: *

Belfast

Cambridge

Other

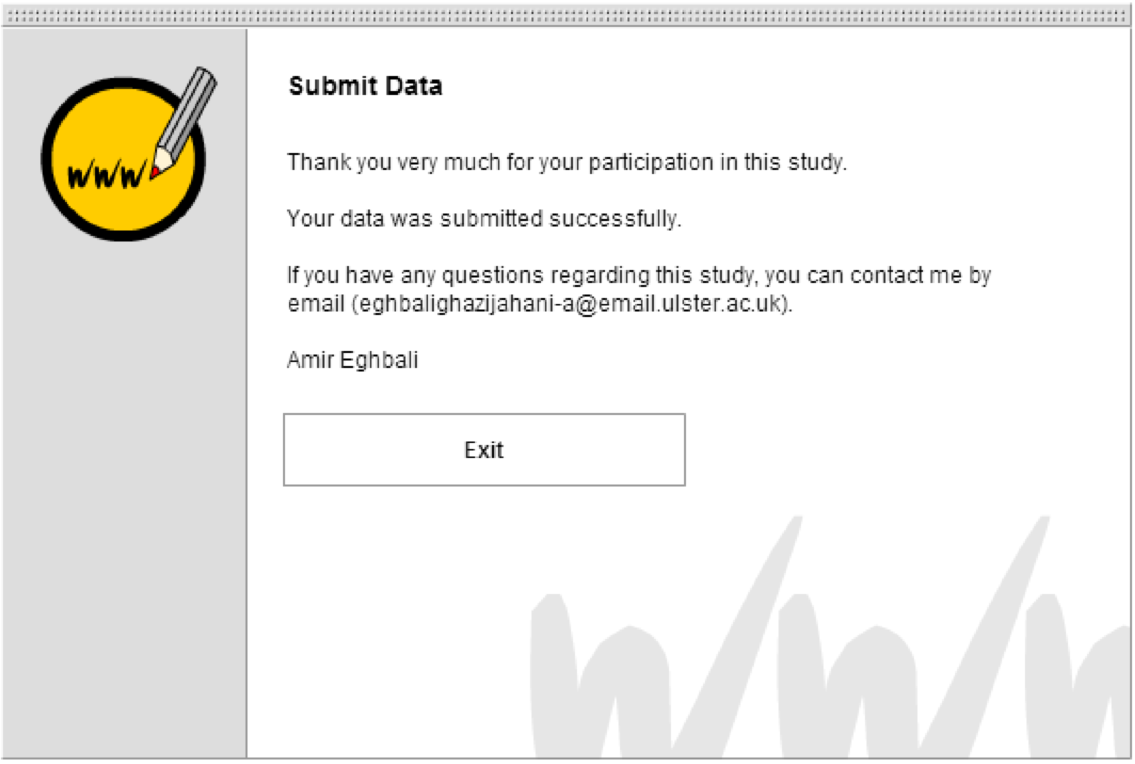


85%

Submit Data

You've finished the survey. Please submit your data now.

Submit data


Submit Data
Thank you very much for your participation in this study.
Your data was submitted successfully.
If you have any questions regarding this study, you can contact me by email (eghbalighazijahani-a@email.ulster.ac.uk).
Amir Eghbali
Exit

Bibliography

ABDUL KADER, S., MUSTAFA, M. & SUFIAN, A. Climate Change Adaptation and Mitigation Through Land Use Decision Making in Malaysia. International Conference on Public Policy and Social Science, 2012.

ABOWITZ, D. A. & TOOLE, T. M. 2010. Mixed Method Research: Fundamental Issues of Design, Validity, and Reliability in Construction Research. *Journal of Construction Engineering and Management,* 136**,** 108-116.

ADGER, N., ARNELL, N. W. & TOMPKINS, E. L. 2005. Successful adaptation to climate change across scales. *Global Environmental Change,* 15**,** 77-86.

ADGER, W., DESSAI, S., GOULDEN, M., HULME, M., LORENZONI, I., NELSON, D., NAESS, L., WOLF, J. & WREFORD, A. 2009. Are there social limits to adaptation to climate change? *Climatic Change,* 93**,** 335-354.

ADGER, W. N. 2001. Scales of governance and environmental justice for adaptation and mitigation of climate change. *Journal of International Development,* 13**,** 921-931.

ADGER, W. N., BARNETT, J., BROWN, K., MARSHALL, N. & O'BRIEN, K. 2013. Cultural dimensions of climate change impacts and adaptation. *Nature Clim. Change,* 3**,** 112-117.

ADGER, W. N., BROWN, K., FAIRBRASS, J., JORDAN, A., PAAVOLA, J., ROSENDO, S. & SEYFANG, G. 2003. Governance for sustainability: towards athick'analysis of environmental decisionmaking. *Environment and Planning A,* 35**,** 1095-1110.

AGARWAL, A., PERRIN, N., CHHATRE, A., BENSON, C. S. & KONONEN, M. 2012. Climate policy processes, local institutions, and adaptation actions: mechanisms of translation and influence. *Wiley Interdisciplinary Reviews: Climate Change,* 3**,** 565-579.

AHMED, F., ROSE, G. & JACOB, C. Impact of weather on commuter cyclist behaviour and implications for climate change adaptation. Australasian Transport Research Forum (ATRF), 33rd, 2010, Canberra, ACT, Australia, 2010.

AKAIKE, H. 1973. Information theory and an extension of the maximum likelihood principle. *In:* PETROV, B. N. & CSAKI, F. (eds.) *Second International Symposium on Information Theory.* Akademiai Kiado, Budapest.

AKAIKE, H. 1992. Information Theory and an Extension of the Maximum Likelihood Principle. *In:* KOTZ, S. & JOHNSON, N. (eds.) *Breakthroughs in Statistics.* Springer New York.

AKOMPAB, D. A., BI, P., WILLIAMS, S., SANIOTIS, A., WALKER, I. A. & AUGOUSTINOS, M. 2012. Engaging stakeholders in an adaptation process: governance and institutional arrangements in heat-health policy development in Adelaide, Australia. *Mitigation and Adaptation Strategies for Global Change,* 18**,** 1001-1018.

AKRAM, W., HINE, J. & BERRY, J. Transport governance, structures and policy implementation: A methodological framework. Irish Transport Research Network 2011 (ITRN 2011), 2011 Cork, Rebublic of Ireland.

ALLEN, M. R., FRAME, D. J., HUNTINGFORD, C., JONES, C. D., LOWE, J. A., MEINSHAUSEN, M. & MEINSHAUSEN, N. 2009. Warming caused by cumulative carbon emissions towards the trillionth tonne. *Nature,* 458**,** 1163-6.

AMUNDSEN, H., BERGLUND, F. & WESTSKOGÔ, H. 2010. Overcoming barriers to climate change adaptation: a question of multilevel governance? *Environment and Planning C: Government and Policy,* 28**,** 276-289.

ANDEREGG, W. R. L., PRALL, J. W., HAROLD, J. & SCHNEIDER, S. H. 2010. Expert credibility in climate change. *Proceedings of the National Academy of Sciences,* 107**,** 12107-12109.

ANDERSSON, A. K. & CHAPMAN, L. 2011. The impact of climate change on winter road maintenance and traffic accidents in West Midlands, UK. *Accident Analysis & Prevention,* 43**,** 284-289.

ANDREY, J., MILLS, B. & VANDERMOLEN, J. 2001. Weather information and road safety. *Institute for Catastrophic Loss Reduction, Toronto, Ontario, Canada*.

ANTONIO, J. & OLIVEIRA, P. D. 2009. The implementation of climate change related policies at the subnational level: An analysis of three countries. *Habitat International,* 33**,** 253-259.

ANTONSON, H., ISAKSSON, K., STORBJÖRK, S. & HJERPE, M. 2016. Negotiating climate change responses: Regional and local perspectives on transport and coastal zone planning in South Sweden. *Land Use Policy,* 52**,** 297-305.

ARBUCKLE, J. G., JR., MORTON, L. & HOBBS, J. 2013. Farmer beliefs and concerns about climate change and attitudes toward adaptation and mitigation: Evidence from Iowa. *Climatic Change,* 118**,** 1-13.

ARMATAS, C., VENN, T. & WATSON, A. 2016. Understanding social–ecological vulnerability with Q-methodology: a case study of water-based ecosystem services in Wyoming, USA. *Sustainability Science***,** 1-17.

ARNELL, N. 2010. Adapting to climate change: an evolving research programme. *Climatic Change,* 100**,** 107-111.

ARNELL, N. W., LOWE, J. A., BROWN, S., GOSLING, S. N., GOTTSCHALK, P., HINKEL, J., LLOYD-HUGHES, B., NICHOLLS, R. J., OSBORN, T. J., OSBORNE, T. M., ROSE, G. A., SMITH, P. & WARREN, R. F. 2013. A global assessment of the effects of climate policy on the impacts of climate change. *Nature Clim. Change,* 3**,** 512–519.

ASAH, S. T., BENGSTON, D. N., WENDT, K. & NELSON, K. C. 2012. Diagnostic reframing of intractable environmental problems: Case of a contested multiparty public land-use conflict. *Journal of Environmental Management,* 108**,** 108-119.

ASC-CCC 2010. How well prepared is the UK for climate change? : Committee on Climate Change, Adaptation Sub-Committee.

ASC-CCC 2011. How well is Scotland Preparing for Climate Change? : Adaptation Sub Committe of Climate Change Committee.

ASC-CCC 2012. Climate change – is the UK preparing for flooding and water scarcity? : Adaptation Sub-Committee, Progress Report 2012.

ATE 2005. Objective Setting for Climate Change Adaptation Policy. AEA Technology Environment, Stockholm Environment Institute.

BABBIE, E. R. 2010. *The practice of social research,* Belmont, Calif, Wadsworth Cengage.

BACHE, I., BARTLE, I., FLINDERS, M. & MARSDEN, G. 2015a. Blame Games and Climate Change: Accountability, Multi-Level Governance and Carbon Management. *The British Journal of Politics & International Relations,* 17**,** 64-88.

BACHE, I., REARDON, L., BARTLE, I., FLINDERS, M. & MARSDEN, G. 2015b. Symbolic Meta-Policy: (Not) Tackling Climate Change in the Transport Sector. *Political Studies,* 63**,** 830-851.

BAHADUR, A. V., IBRAHIM, M. & TANNER, T. 2010. The resilience renaissance. *Unpacking of resilience for tackling climate change and disasters. Strengthening Climate Resilience Discussion Paper.* Brighton: Institute of Development Studies.

BAJIĆ-BRKOVIĆ, M., SRETOVIĆ, V. & BRKOVIĆ, M. 2012. Low carbon urban development in Serbia: Challenges and opportunities on the local level. *Facta universitatis-series: Architecture and Civil Engineering,* 10**,** 43-53.

BARRETT, S. M. 2004. Implementation Studies: Time for a Revival? Personal Reflections on 20 Years of Implementation Studies. *Public Administration,* 82**,** 249-262.

BARROW, C. 2006. *Environmental Management for Sustainable Development*, Taylor & Francis.

BARRY, J. & PROOPS, J. 1999. Seeking sustainability discourses with Q methodology. *Ecological Economics,* 28**,** 337-345.

BAYLISS, J., DAVIES, N., GLUCKMAN, C., SIMPSON, A., HYDE, P. & GOLDSMITH, J. 2009. Adapting to Climate Change: A review for the environmental audit committee. *In:* OFFICE, N. A. (ed.). London.

BAZELE, P. 2002. Issues in mixing qualitative and quantitative approaches to research. *1st International Conference - Qualitative Research in Marketing and Management.* University of Economics and Business Administration, Vienna.

BEG, N., MORLOT, J. C., DAVIDSON, O., AFRANE-OKESSE, Y., TYANI, L., DENTON, F., SOKONA, Y., THOMAS, J. P., LA ROVERE, E. L., PARIKH, J. K., PARIKH, K. & RAHMAN, A. A. 2002. Linkages between climate change and sustainable development. *Climate Policy,* 2**,** 129-144.

BENZIE, M., HARVEY, A. & MILLER, K. 2011. Adaptation in UK Cities: Heading in the Right Direction?

Resilient Cities. *In:* OTTO-ZIMMERMANN, K. (ed.). Springer Netherlands.

BERG, V. D. M. & COENEN, F. 2012. Integrating climate change adaptation into Dutch local policies and the role of contextual factors. *Local Environment,* 17**,** 441-460.

BERMAN, M. & KOFINAS, G. 2004. Hunting for models: grounded and rational choice approaches to analyzing climate effects on subsistence hunting in an Arctic community. *Ecological Economics,* 49**,** 31-46.

BERMAN, P. 1980. Thinking about Programmed and Adaptive Implementation: Matching Strategies to Situation. *In:* INGRAM, H. & MANN, D. (eds.) *Why Policies Succeed or Fail.* Sage Publications.

BERRANG-FORD, L., PEARCE, T. & FORD, J. 2015. Systematic review approaches for climate change adaptation research. *Regional Environmental Change,* 15**,** 755-769.

BIERBAUM, R., SMITH, J. B., LEE, A., BLAIR, M., CARTER, L., CHAPIN, F. S., FLEMING, P., RUFFO, S., STULTS, M., MCNEELEY, S., WASLEY, E. & VERDUZCO, L. 2013. A comprehensive review of climate adaptation in the United States: more than before, but less than needed. *Mitigation and Adaptation Strategies for Global Change,* 18**,** 361-406.

BIESBROEK, G. R., SWART, R. J., CARTER, T. R., COWAN, C., HENRICHS, T., MELA, H., MORECROFT, M. D. & REY, D. 2010. Europe adapts to climate change: Comparing National Adaptation Strategies. *Global Environmental Change,* 20**,** 440-450.

BINDER, K. & HEERMANN, D. 2010. *Monte Carlo simulation in statistical physics: an introduction*, Springer.

BIRKLAND, T. A. 2010. *An Introduction to the Policy Process: Theories, Concepts, and Models of Public Policy Making*, M E Sharpe Incorporated.

BIRKMANN, J., GARSCHAGEN, M., KRAAS, F. & QUANG, N. 2010. Adaptive urban governance: new challenges for the second generation of urban adaptation strategies to climate change. *Sustainability Science,* 5**,** 185-206.

BLAU, P. 1997. On limitations of rational choice theory for sociology. *The American Sociologist,* 28**,** 16-21.

BLOOR, M., FRANKLAND, J., THOMAS, M. & ROBSON, K. 2001. *Focus Groups in Social Research*, Sage Publications.

BÖCKER, L., DIJST, M. & PRILLWITZ, J. 2012. Impact of Everyday Weather on Individual Daily Travel Behaviours in Perspective: A Literature Review. *Transport Reviews,* 33**,** 71-91.

BOEIJE, H. 2002. A Purposeful Approach to the Constant Comparative Method in the Analysis of Qualitative Interviews. *Quality & Quantity,* 36**,** 391-409.

BOSCOLO, P. & CISOTTO, L. 1999. Instructional strategies for teaching to write: a Q-sort analysis. *Learning and Instruction,* 9**,** 209-221.

BOUWMAN, H., BEJAR, A. & NIKOU, S. 2012. Mobile services put in context: A Q-sort analysis. *Telematics and Informatics,* 29**,** 66-81.

BOYD, E., STREET, R., GAWITH, M., LONSDALE, K., NEWTON, L., JOHNSTONE, K. & METCALF, G. 2011. Leading the UK Adaptation Agenda: A Landscape of Stakeholders and Networked Organizations for Adaptation to Climate Change *In:* FORD, J. D. & BERRANG-FORD, L. (eds.) *Climate Change Adaptation in Developed Nations.* Springer Netherlands.

BRANDENBURG, C., MATZARAKIS, A. & ARNBERGER, A. 2007. Weather and cycling—a first approach to the effects of weather conditions on cycling. *Meteorological Applications,* 14**,** 61-67.

BREEN, P. & ANDERIES, J. M. 2011. Resilience: A Literature Review. New York: Rockefeller Foundation.

BREEN, R. L. 2006. A Practical Guide to Focus-Group Research. *Journal of Geography in Higher Education,* 30**,** 463-475.

BRODT, S., KLONSKY, K. & TOURTE, L. 2006. Farmer goals and management styles: Implications for advancing biologically based agriculture. *Agricultural Systems,* 89**,** 90-105.

BROUWER, S., RAYNER, T. & HUITEMA, D. 2013. Mainstreaming climate policy: the case of climate adaptation and the implementation of EU water policy. *Environment and Planning C: Government and Policy,* 31, 134-153.

BROWN, S., DANIELSON, S. & EXEL, J. 2014. Overly ambitious critics and the Medici Effect: a reply to Kampen and Tamás. *Quality & Quantity*, 1-15.

BROWN, S. R. 1980. *Political subjectivity: applications of Q methodology in political science*, Yale University Press.

BROWN, S. R. 1993. A primer on Q methodology. *Operant subjectivity,* 16, 91-138.

BROWN, S. R. 1996. Q methodology and qualitative research. *Qualitative health research,* 6, 561-567.

BRUINSMA, F. R., RIENSTRA, S. A. & RIETVELD, P. 1997. Economic Impacts of the Construction of a Transport Corridor: A Multi-level and Multiapproach Case Study for the Construction of the A1 Highway in the Netherlands. *Regional Studies,* 31, 391-402.

BRYANT, L. D., AHMED, S., AHMED, M., JAFRI, H. & RAASHID, Y. 2011. 'All is done by Allah'. Understandings of Down syndrome and prenatal testing in Pakistan. *Social Science & Medicine,* 72, 1393-1399.

BRYNARD, P. 2005. Policy implementation: lessons for service delivery. *Journal of Public Administration,* 40, 649-664.

BUCKLEY, C. 2012. Implementation of the EU Nitrates Directive in the Republic of Ireland — A view from the farm. *Ecological Economics,* 78, 29-36.

BULKELEY, H. 2009. Planning and governance of climate change. *In:* DAVOUDI, S., CRAWFORD, J. & MEHMOOD, A. (eds.) *Planning for climate change: strategies for mitigation and adaptation for spatial planners.* London: Earthscan/James & James.

BULKELEY, H., SCHROEDER, H., JANDA, K., ZHAO, J., ARMSTRONG, A., CHU, S. Y. & GHOSH, S. 2011. Cities and Climate Change: The role of institutions, governance and urban planning. *Fifth Urban Research Symposium, Cities and Climate Change: Responding to an Urgent Agenda.* Marseille, France.

BURNEY, S. M. A. 2008. Inductive and Deductive research approach. Department of Computer Science, University of Karachi.

BURNHAM, K. P. & ANDERSON, D. R. 2002. *Model Selection and Multi-Model Inference: A Practical Information-Theoretic Approach,* Colorado State University, Fort Collins, USA, Springer.

BURTON, P. Climate change and public policy: three challenges. Public Policy Network Conference, 29-30 January 2009 2009 The australian National University, Canberra.

BYERS, P. Y. & WILCOX, J. R. 1991. Focus Groups: A Qualitative Opportunity for Researchers. *Journal of Business Communication,* 28**,** 63-78.

CAMHIS, M. 1979. *Planning Theory and Philosophy*, Tavistock Publications.

CANTARELLI, C. C., VAN WEE, B., MOLIN, E. J. E. & FLYVBJERG, B. 2012. Different cost performance: different determinants?: The case of cost overruns in Dutch transport infrastructure projects. *Transport Policy,* 22**,** 88-95.

CAPSTICK, S. B. & PIDGEON, N. F. 2014. What is climate change scepticism? Examination of the concept using a mixed methods study of the UK public. *Global Environmental Change,* 24**,** 389-401.

CARIFIO, J. & PERLA, R. J. 2007. Ten Common Misunderstandings, Misconceptions, Persistent Myths and Urban Legends about Liker Scales and Liker Response Formats and their Antidotes. *Journal of Social Sciences (15493652),* 3.

CARLSSON-KANYAMA, A., CARLSEN, H. & DREBORG, K.-H. 2013. Barriers in municipal climate change adaptation: results from case studies using backcasting. *Futures,* accepted manuscript.

CARMIN, J. A., ANGUELOVSKI, I. & ROBERTS, D. 2012. Urban Climate Adaptation in the Global South Planning in an Emerging Policy Domain. *Journal of Planning Education and Research,* 32**,** 18-32.

CARRILLO, P. & CHINOWSKY, P. 2013. Climate change adaptation and roads: Dutch case study of cost impacts at the organization level. *Engineering Project Organization Conference.* Devil's Thumb Ranch, Colorado.

CARTER, J. G. 2011. Climate change adaptation in European cities. *Current Opinion in Environmental Sustainability,* 3**,** 193-198.

CASTÁN BROTO, V. & BULKELEY, H. 2013. A survey of urban climate change experiments in 100 cities. *Global Environmental Change,* 23**,** 92-102.

CCIRG 1991. The potential effects of climate change in the United Kingdom. *In:* ENVIRONMENT, D. O. T. (ed.). London.

CCIRG 1996. Review of the potential effects of climate change in the United Kingdom. *In:* ENVIRONMENT, D. O. T. (ed.). London.

CELLIERS, L., ROSENDO, S., COETZEE, I. & DANIELS, G. 2013. Pathways of integrated coastal management from national policy to local implementation: Enabling climate change adaptation. *Marine Policy,* 39**,** 72-86.

CFIT 2010. Transport Challenges and Opportunities: Getting more from less The National Archives: Commission for Integrated Transport.

CHANEY, P. 2014. Mixed-methods analysis of political parties' manifesto discourse on rail transport policy: Westminster, Scottish, Welsh and Northern Irish elections 1945–2011. *Transport Policy,* 35, 275-285.

CHANG, L.-F., SETO, K. & HUANG, S.-L. 2013. Climate Change, Urban Flood Vulnerability, and Responsibility in Taipei. *In:* BOONE, C. G. & FRAGKIAS, M. (eds.) *Urbanization and Sustainability.* Springer Netherlands.

CHANG, S. O., KIM, J. H., KONG, E. S., KIM, C. G., AHN, S. Y. & CHO, N. O. 2008. Exploring ego-integrity in old adults: a Q-methodology study. *International Journal of Nursing Studies,* 45, 246-56.

CHAPMAN, L. 2007. Transport and climate change: a review. *Journal of Transport Geography,* 15, 354-367.

CHEN, J.-H. & FANG, Y.-P. 2011. A study on the modified components of Asian Currency Unit: an application of the Artificial Neural Network. *Quality & Quantity,* 45, 329-347.

CHINNIS, A. S., PAULSON, D. J. & DAVIS, S. M. 2001. Using Q methodology to assess the needs of Emergency Medicine support staff employees. *The Journal of Emergency Medicine,* 20, 197-203.

CHINOWSKY, P. S., PRICE, J. C. & NEUMANN, J. E. 2013. Assessment of climate change adaptation costs for the U.S. road network. *Global Environmental Change,* 23, 764-773.

CHUNG, E., OHTANI, O., WARITA, H., KUWAHARA, M. & MORITA, H. Effect of rain on travel demand and traffic accidents. Intelligent Transportation Systems, 2005. Proceedings. 2005 IEEE, 13-15 Sept. 2005 2005. 1080-1083.

CLARE, S., KROGMAN, N. & CAINE, K. J. 2013. The "balance discourse": A case study of power and wetland management. *Geoforum,* 49, 40-49.

COLE, D. H. 2008. Stern Review and Its Critics: Implications for the Theory and Practice of Benefit-Cost Analysis, The. *Nat. Resources J.,* 48, 53-90.

COOLS, M., BRIJS, K., TORMANS, H., DE LAENDER, J. & WETS, G. 2012. Optimizing the implementation of policy measures through social acceptance segmentation. *Transport Policy,* 22, 80-87.

COOLS, M., MOONS, E., JANSSENS, B. & WETS, G. 2009. Shifting towards environment-friendly modes: profiling travelers using Q-methodology. *Transportation,* 36, 437-453.

CORFEE-MORLOT, J., CO-OPERATION, O. F. E. & DIRECTORATE, D. E. 2009. *Cities, climate change and multilevel governance*, OECD publishing.

CORFEE-MORLOT, J., COCHRAN, I., HALLEGATTE, S. & TEASDALE, P.-J. 2011. Multilevel risk governance and urban adaptation policy. *Climatic Change,* 104, 169-197.

CORNER, A., MARKOWITZ, E. & PIDGEON, N. 2014. Public engagement with climate change: the role of human values. *Wiley Interdisciplinary Reviews: Climate Change,* 5**,** 411-422.

COTE, M. 2011. Barriers to implementing climate adaptation plans: a survey of climate professionals across sectors. *Complementary summary.* Washington: Association of Climate Change Officers.

CRAFT, J., HOWLETT, M., CRAWFORD, M. & MCNUTT, K. 2013. Assessing Policy Capacity for Climate Change Adaptation: Governance Arrangements, Resource Deployments, and Analytical Skills in Canadian Infrastructure Policy Making. *Review of Policy Research,* 30**,** 42-65.

CRAFTS, N. & LEUNIG, T. 2005. The Historical Significance for Economic Growth and Productivity.

CRESWELL, J. W. 2012. *Educational research : planning, conducting, and evaluating quantitative and qualitative research,* Boston, Pearson.

CREUTZIG, F., GOLDSCHMIDT, J. C., LEHMANN, P., SCHMID, E., VON BLÜCHER, F., BREYER, C., FERNANDEZ, B., JAKOB, M., KNOPF, B., LOHREY, S., SUSCA, T. & WIEGANDT, K. 2014. Catching two European birds with one renewable stone: Mitigating climate change and Eurozone crisis by an energy transition. *Renewable and Sustainable Energy Reviews,* 38**,** 1015-1028.

CROSS-SUDWORTH, F., WILLIAMS, A. & HERRON-MARX, S. 2011. Maternity services in multi-cultural Britain: using Q methodology to explore the views of first- and second-generation women of Pakistani origin. *Midwifery,* 27**,** 458-468.

CROWLEY, T. J. 2000. Causes of Climate Change Over the Past 1000 Years. *Science,* 289**,** 270-277.

CULLINGWORTH, J. B. & NADIN, V. 2002. *Town and Country Planning in the UK,* London, Routledge.

CUPPEN, E., BREUKERS, S., HISSCHEMÖLLER, M. & BERGSMA, E. 2010. Q methodology to select participants for a stakeholder dialogue on energy options from biomass in the Netherlands. *Ecological Economics,* 69**,** 579-591.

CURRY, R., BARRY, J. & MCCLENAGHAN, A. 2012. Northern Visions? Applying Q methodology to understand stakeholder views on the environmental and resource dimensions of sustainability. *Journal of Environmental Planning and Management***,** 1-26.

DANIELSON, S. 2009. Q method and surveys: Three ways to combine Q and R. *Field Methods,* 21**,** 219-237.

DANNEVIG, H., RAUKEN, T. & HOVELSRUD, G. 2012. Implementing adaptation to climate change at the local level. *Local Environment,* 17**,** 597-611.

DAVOUDI, S. & MEHMOOD, A. 2010. ARCADIA - Adaptation and Resilience in Cities: Analysis and Decision-making using Integrated Assessment. *Task 1 Initial Report: Governance of Climate Change Adaptation in London.* The Adaptation and Resilience in a Changing Climate (ARCC)

DCLG 2012. National Planning Policy Framework. *In:* GOVERNMENT, D. F. C. A. L. (ed.). Department for Communities and Local Government.

DE GRAAF, G. & VAN EXEL, J. 2008. Using Q methodology in administrative ethics. *Public Integrity,* 11**,** 63-78.

DECC 2008. Climate Change Act 2008: Impact Assessment.

DEFRA 2008. *Adapting to climate change in England: a framework for action,* London, Department for Environment, Food and Rural Affairs.

DEFRA 2009. Adapting to climate change: UK Climate Projections *In:* DEPARTMENT FOR ENVIRONMENT, F. A. R. A. (ed.).

DEFRA. 2011a. *Adapting to Climate Change Programme (ACC)* [Online]. Available: http://www.ukcip.org.uk/government/central-government/acc/ [Accessed 03 March 2012].

DEFRA 2011b. Climate resilient infrastructure : preparing for a changing climate. TSO.

DEFRA 2012a. Climate Change Risk Assessment for Northern Ireland. *In:* DEPARTMENT FOR ENVIRONMENT, F. A. R. A. (ed.).

DEFRA 2012b. Climate Change Risk Assessment for Scotland. *In:* DEPARTMENT FOR ENVIRONMENT, F. A. R. A. (ed.).

DEFRA 2012c. Climate Change Risk Assessment for the Transport Sector. *In:* DEPARTMENT FOR ENVIRONMENT, F. A. R. A. (ed.).

DEFRA 2012d. Climate Change Risk Assessment for the Transport Sector (summary report). *In:* DEPARTMENT FOR ENVIRONMENT, F. A. R. A. (ed.).

DEFRA 2012e. Climate Change Risk Assessment: Business, Industry and Services. *In:* DEPARTMENT FOR ENVIRONMENT, F. A. R. A. (ed.). London.

DEFRA. 2012f. *UK Climate Change Risk Assessment (CCRA)* [Online]. Available: http://www.defra.gov.uk/environment/climate/government/risk-assessment/#sectors [Accessed 12 May 2012].

DEFRA 2012g. UK climate change risk assessment: Government report. *In:* DEPARTMENT FOR ENVIRONMENT, F. A. R. A. (ed.).

DEFRA 2013. The National Adaptation Programme: Making the country resilient to a changing climate. *In:* DEPARTMENT FOR ENVIRONMENT, F. A. R. A. (ed.). London.

DEPENAU, J. 1995. *Automated Design of Neural Network Architecture for Classication.* PhD, Aarhus University.

DETR 2000. Climate Change: The UK Programme. *In:* BRETAGNE, G. (ed.). Department of the Environment, Transport and the Regions, Stationery Office.

DETR, A. 1998. New Deal for Transport: Better for everyone. *In:* DEPARTMENT OF THE ENVIRONMENT, T. A. T. R. (ed.) *The Government's White Paper on the Future of Transport, The Stationery Office, London.*

DFT 2004. The Future of Transport: A Network for 2030. *In:* TRANSPORT, D. F. (ed.). Stationery Office.

DFT 2007. Towards a Sustainable Transport System: Supporting Economic Growth in a Low Carbon World. *In:* TRANSPORT, D. F. (ed.). Stationery Office.

DFT 2009. The Highways Agency: Framework Document. *In:* TRANSPORT, D. F. (ed.).

DFT 2010a. Building Resilience to Climate Change: An Adaptation Plan for Transport 2010-2012. *In:* TRANSPORT, D. F. (ed.). London.

DFT 2010b. The Resilience of England’s Transport Systems in Winter. *In:* TRANSPORT, D. F. (ed.). London.

DFT 2011a. Creating Growth, Cutting Carbon Making Sustainable Local Transport Happen. *In:* TRANSPORT, D. F. (ed.). London.

DFT 2011b. Departmental Adaptation, Plan Update. *In:* TRANSPORT, D. F. (ed.).

DISETH, R. R., BØGWALD, K.-P. & HØGLEND, P. A. 2011. Attitudes among stakeholders towards compulsory mental health care in Norway. *International Journal of Law and Psychiatry,* 34**,** 1-6.

DOCHERTY, I. & SHAW, J. 2003. *A New Deal for Transport?: The Uk's Struggle With the Sustainable Transport Agenda*, Blackwell Pub.

DOCHERTY, I. & SHAW, J. 2008. *Traffic Jam: Ten Years of 'Sustainable' Transport in the UK*, Policy Press.

DOCHERTY, I. & SHAW, J. 2009. Governance, Transport. *In:* EDITORS-IN-CHIEF: ROB, K. & NIGEL, T. (eds.) *International Encyclopedia of Human Geography.* Oxford: Elsevier.

DOENI. 2012a. *Climate Change Adaptation Programme* [Online]. Available: http://www.doeni.gov.uk/index/protect_the_environment/climate_change/climate_change_adaptation_programme.htm [Accessed 17 May 2012].

DOENI. 2012b. *Cross-Departmental Working Group* [Online]. Available: http://www.doeni.gov.uk/index/protect_the_environment/climate_change/climate_change_adaptation_way_forward.htm [Accessed 17 May 2012].

DOENI. 2012c. *Powers and Functions: Local Government Powers and Duties* [Online]. Available: http://www.doeni.gov.uk/index/local_government/council_structure/powers_and_functions1.htm [Accessed 18 May 2012].

DOENI 2014. Northern Ireland Climate Change Adaptation Programme. *In:* ENVIRONMENT, D. O. T. (ed.). Belfast.

DONNER, J. C. 2001a. Social Development Papers: Paper Number 36. *Using q-sorts in participatory processes: An introduction to the methodology.* Washington, D.C.: The World Bank.

DONNER, J. C. 2001b. Using q-sorts in participatory processes: An introduction to the methodology. *Social Development Papers: Paper Number 36.* Washington, D.C.: The World Bank.

DRDNI 2002. Ensuring a Sustainable Transport Future: A New Approach to Regional Transportation. *In:* DEVELOPMENT, D. F. R. (ed.).

DRDNI 2004. Belfast Metropolitan Transport Plan (BMTP). *In:* (DRD), D. F. R. D. (ed.).

DRDNI 2008. DRD Investment Delivery Plan (IDP) for Roads. *In:* DEVELOPMENT, D. F. R. (ed.).

DRDNI 2012a. Regional Development Strategy (RDS) 2035: Building a Better Future. *In:* DEVELOPMENT, D. F. R. (ed.).

DRDNI. 2012b. *Road Improvements - Introduction* [Online]. Department for Regional Development Northern Ireland. Available: http://www.drdni.gov.uk/index/aboutus.htm [Accessed 18 May 2012].

DRISCOLL, D. L., APPIAH-YEBOAH, A., SALIB, P. & RUPERT, D. J. 2007. Merging qualitative and quantitative data in mixed methods research: How to and why not. *Ecological and Environmental Anthropology (University of Georgia),* 3**,** 19-28.

DUENCKMANN, F. 2010. The village in the mind: Applying Q-methodology to re-constructing constructions of rurality. *Journal of Rural Studies,* 26**,** 284-295.

DUGGLEBY, W. 2005. What about focus group interaction data? *Qualitative health research,* 15**,** 832-840.

DUNLAP, R. E. & MCCRIGHT, A. M. 2008. A widening gap: Republican and Democratic views on climate change. *Environment: Science and Policy for Sustainable Development,* 50**,** 26-35.

DZIOPA, F. & AHERN, K. 2011. A systematic literature review of the applications of Q-technique and its methodology. *Methodology: European Journal of Research Methods for the Behavioral and Social Sciences,* 7**,** 39.

EAC 2010. Adapting to Climate Change: Sixth Report of Session 2009–10. *In:* HOUSE OF COMMONS, E. A. C. (ed.).

EDDINGTON, R. 2006. The Eddington transport study. *For DfT and HM Treasury, UK*.

EICHHORST, U. 2009. Sustainable Transport: A Sourcebook for Policy-Makers in Developing Cities. *In:* FÜR, D. G. (ed.) *Adapting Transport in Developing Cities to Climate Change.* Eschborn.

EISENACK, K., STECKER, R., RECKIEN, D. & HOFFMANN, E. 2012. Adaptation to climate change in the transport sector: a review of actions and actors. *Mitigation and Adaptation Strategies for Global Change,* 17**,** 451-469.

ELMORE, R. F. 1979. Backward mapping: Implementation research and policy decisions. *Political science quarterly,* 94**,** 601-616.

ENVIRONMENT-AGENCY. 2012. *Adaptation Planning: Summary of the Environment Agency's role in adaptation* [Online]. Available: http://www.environment-agency.gov.uk/research/planning/132423.aspx [Accessed].

ERIKSEN, S., ALDUNCE, P., BAHINIPATI, C. S., MARTINS, R. D. A., MOLEFE, J. I., NHEMACHENA, C., O'BRIEN, K., OLORUNFEMI, F., PARK, J., SYGNA, L. & ULSRUD, K. 2011. When not every response to climate change is a good one: Identifying principles for sustainable adaptation. *Climate and Development,* 3**,** 7-20.

ERIKSSON, K., ESTEP, D. & JOHNSON, C. 2004. *Applied Mathematics: Body and Soul: Volume 1: Derivatives and Geometry in IR3*, Springer.

ETZIONI, A. 1967. Mixed-scanning: A" third" approach to decision-making. *Public administration review***,** 385-392.

EXEL, J. & GRAAF, G. 2005. Q methodology: A sneak preview. Available: http://qmethod.org/articles/vanExel.pdf [Accessed 27 Aug 2013].

FATTI, C. E. & PATEL, Z. 2013. Perceptions and responses to urban flood risk: Implications for climate governance in the South. *Applied Geography,* 36**,** 13-22.

FAUSETT, L. V. 1994. *Fundamentals of Neural Networks: Architectures, Algorithms, and Applications*, Prentice Hall International.

FEW, R., BROWN, K. & TOMPKINS, E. L. 2007. Climate Change and Coastal Management Decisions: Insights from Christchurch Bay, UK. *Coastal Management,* 35, 255-270.

FIDELMAN, P. I. J., LEITCH, A. M. & NELSON, D. R. 2013. Unpacking multilevel adaptation to climate change in the Great Barrier Reef, Australia. *Global Environmental Change,* article in press.

FIELD, A. P. 2005. Kendall's Coefficient of Concordance. *Encyclopedia of Statistics in Behavioral Science.* John Wiley & Sons, Ltd.

FLORES, J. A. 2011. *Focus on Artificial Neural Networks*, Nova Science Publishers, Incorporated.

FLYVBJERG, B. 2007. Policy and planning for large-infrastructure projects: problems, causes, cures. *Environment and Planning B: Planning and Design,* 34, 578-597.

FLYVBJERG, B., HOLM, M. S. & BUHL, S. 2002. Underestimating Costs in Public Works Projects: Error or Lie? *Journal of the American Planning Association,* 68, 279-295.

FRANKEL, R. M. & DEVERS, K. J. 2000. Study design in qualitative research-1: Developing questions and assessing resource needs. *Education for Health: Change in Learning &# 38; Practice,* 13, 251-261.

FRANTZI, S., CARTER, N. T. & LOVETT, J. C. 2009. Exploring discourses on international environmental regime effectiveness with Q methodology: A case study of the Mediterranean Action Plan. *Journal of Environmental Management,* 90, 177-186.

FRÖHLICH, J. & KNIELING, J. 2013. Conceptualising Climate Change Governance. *In:* KNIELING, J. & LEAL FILHO, W. (eds.) *Climate Change Governance.* Springer Berlin Heidelberg.

FUCHS, G. 2014. The Governance of Innovations in the Energy Sector. *Science & Technology,* 27, 34-53.

FÜNFGELD, H. 2010. Institutional challenges to climate risk management in cities. *Current Opinion in Environmental Sustainability,* 2, 156-160.

FÜSSEL, H.-M. & KLEIN, R. 2006. Climate Change Vulnerability Assessments: An Evolution of Conceptual Thinking. *Climatic Change,* 75, 301-329.

GAFFRON, P. 2003. The implementation of walking and cycling policies in British local authorities. *Transport Policy,* 10, 235-244.

GARCÍA DE JALÓN, S., IGLESIAS, A., QUIROGA, S. & BARDAJÍ, I. 2013. Exploring public support for climate change adaptation policies in the Mediterranean region: A case study in Southern Spain. *Environmental Science & Policy*.

GEORGESON, L., MASLIN, M., POESSINOUW, M. & HOWARD, S. 2016. Adaptation responses to climate change differ between global megacities. *Nature Clim. Change,* advance online publication.

GILLETT, N. P., ARORA, V. K., ZICKFELD, K., MARSHALL, S. J. & MERRYFIELD, W. J. 2011. Ongoing climate change following a complete cessation of carbon dioxide emissions. *Nature Geosci,* 4**,** 83-87.

GOODWIN, P. 1999. Transformation of transport policy in Great Britain. *Transportation Research Part A: Policy and Practice,* 33**,** 655-669.

GORDON, R. F. S. 2011. Sustainable Development: Responding to the Research Challenge in the Land of the Long White Cloud, Aotearoa New Zealand

European Research on Sustainable Development. *In:* JAEGER, C. C., TÀBARA, J. D. & JAEGER, J. (eds.). Springer Berlin Heidelberg.

GREAKER, M., STOKNES, P. E., ALFSEN, K. H. & ERICSON, T. 2013. A Kantian approach to sustainable development indicators for climate change. *Ecological Economics,* 91**,** 10-18.

GREEN, S. L. 2002. Rational choice theory: An overview.

GREGORY, R. 1989. Political Rationality or 'Incrementalism'? Charles E. Lindblom's enduring contribution to public policy making theory. *Policy & Politics,* 17**,** 139-153.

GROTHMANN, T. 2011. Governance Recommendations for Adaptation in European Urban Regions: Results from Five Case Studies and a European Expert Survey

Resilient Cities. *In:* OTTO-ZIMMERMANN, K. (ed.). Springer Netherlands.

GROTHMANN, T. & PATT, A. 2005. Adaptive capacity and human cognition: The process of individual adaptation to climate change. *Global Environmental Change,* 15**,** 199-213.

GROVER, H. 2013. *Local response to global Climate Change: The role of local development plans in Climate Change management* [Online]. Texas A&M University at College Station Available: http://repositories.tdl.org/tdl-ir/handle/1969.1/ETD-TAMU-2010-08-8461 [abstract only] [Accessed 08 March 2013 2013].

GRUBER, J. S. 2010. Key principles of community-based natural resource management: a synthesis and interpretation of identified effective approaches for managing the commons. *Environmental management,* 45**,** 52-66.

GRUBER, J. S. 2011. Perspectives of effective and sustainable community-based natural resource management: An application of Q methodology to forest projects. *Conservation & Society,* 9.

GUPTA, J. 2007a. The multi-level governance challenge of climate change. *Environmental Sciences,* 4**,** 131-137.

GUPTA, J. 2010. A history of international climate change policy. *Wiley Interdisciplinary Reviews: Climate Change,* 1**,** 636-653.

GUPTA, K. 2007b. Urban flood resilience planning and management and lessons for the future: a case study of Mumbai, India. *Urban Water Journal,* 4**,** 183-194.

HA 2009. Climate Change Adaptation Strategy and Framework. *In:* TRANSPORT, D. F. (ed.).

HA. 2012. *The Highways Agency's Traffic Control Centre Project* [Online]. Available: http://www.highways.gov.uk/knowledge/2034.aspx [Accessed 13 May 2012].

HADDAD, B. M. 2005. Ranking the adaptive capacity of nations to climate change when socio-political goals are explicit. *Global Environmental Change,* 15**,** 165-176.

HAGUE, P. 2006. A Practical Guide to Market Research. Grosvenor House.

HALL, C. 2008. Identifying farmer attitudes towards genetically modified (GM) crops in Scotland: Are they pro- or anti-GM? *Geoforum,* 39**,** 204-212.

HALL, C. & WREFORD, A. 2012. Adaptation to climate change: the attitudes of stakeholders in the livestock industry. *Mitigation and Adaptation Strategies for Global Change,* 17**,** 207-222.

HALLEGATTE, S. & CORFEE-MORLOT, J. 2011. Understanding climate change impacts, vulnerability and adaptation at city scale: an introduction. *Climatic Change,* 104**,** 1-12.

HALLEGATTE, S., RANGER, N., MESTRE, O., DUMAS, P., CORFEE-MORLOT, J., HERWEIJER, C. & WOOD, R. 2011. Assessing climate change impacts, sea level rise and storm surge risk in port cities: a case study on Copenhagen. *Climatic Change,* 104**,** 113-137.

HANGER, S., PFENNINGER, S., DREYFUS, M. & PATT, A. 2013. Knowledge and information needs of adaptation policy-makers: a European study. *Regional Environmental Change,* 13**,** 91-101.

HANSON, S., NICHOLLS, R., RANGER, N., HALLEGATTE, S., CORFEE-MORLOT, J., HERWEIJER, C. & CHATEAU, J. 2011. A global ranking of port cities with high exposure to climate extremes. *Climatic Change,* 104**,** 89-111.

HARRISON, P., HOLMAN, I., COJOCARU, G., KOK, K., KONTOGIANNI, A., METZGER, M. & GRAMBERGER, M. 2013. Combining qualitative and quantitative understanding for exploring cross-sectoral climate change impacts, adaptation and vulnerability in Europe. *Regional Environmental Change,* 13**,** 761-780.

HARRY, S. & MORAD, M. 2013. Sustainable development and climate change: Beyond mitigation and adaptation. *Local Economy*.

HEADICAR, P. 2009. *Transport policy and planning in Great Britain*, Routledge.

HEBB, D. O. 1949,2002. *The Organization of Behavior: A Neuropsychological Theory*, Taylor & Francis.

HEINRICHS, D. & KRELLENBERG, K. 2011. Climate Adaptation Strategies: Evidence from Latin American City-Regions

Resilient Cities. *In:* OTTO-ZIMMERMANN, K. (ed.). Springer Netherlands.

HENSTRA, D. 2012. Toward the Climate-Resilient City: Extreme Weather and Urban Climate Adaptation Policies in Two Canadian Provinces. *Journal of Comparative Policy Analysis: Research and Practice,* 14**,** 175-194.

HERMANS, F., KOK, K., BEERS, P. J. & VELDKAMP, T. 2012. Assessing Sustainability Perspectives in Rural Innovation Projects Using Q-Methodology. *Sociologia Ruralis,* 52**,** 70-91.

HILL, M. 2005. *The public policy process,* New York, Pearson Longman.

HILL, M. 2013. A Starting Point: Understanding Governance, Good Governance and Water Governance. *Climate Change and Water Governance.* Springer Netherlands.

HILL, M. & HUPE, P. 2002. *Implementing public policy : governance in theory and practice,* London Sage.

HINE, J. & PRESTON, J. 2003. Introductory overview. *In:* HINE, J. & PRESTON, J. (eds.) *Integrated Futures and Transport Choices: UK Transport Policy Beyond the 1998 White Paper.*

HJERN, B. 1982. Implementation Research: The Link Gone Missing. *Journal of Public Policy,* 2**,** 301-308.

HJERN, B. & PORTER, D. O. 1981. Implementation Structures: A New Unit of Administrative Analysis. *Organization Studies,* 2**,** 211-227.

HODGSON, G. M. 2012. On the limits of rational choice theory. *Economic Thought,* 1.

HOLLING, C. S. 1973. Resilience and stability of ecological systems. *Annual review of ecology and systematics,* 4**,** 1-23.

HORN, J. 1965. A rationale and test for the number of factors in factor analysis. *Psychometrika,* 30**,** 179-185.

HOWELL, D. C. 2011. *Statistical Methods for Psychology, 8th ed,* Belmont, USA, Wadsworth Cengage Learning.

HOWES, M. 2016. Reforms that Integrate Climate Change Adaptation with Disaster Risk Management Based on the Australian Experience of Bushfires and Floods. *In:* LEAL FILHO, W. (ed.) *Innovation in Climate Change Adaptation.* Cham: Springer International Publishing.

HUGHES, G., CHINOWSKY, P. & STRZEPEK, K. 2010. Development and climate change. *The costs of adapting to climate change for infrastructure.* Washington, DC: The International Bank for Reconstruction and Development, The World Bank.

HUNT, A. & WATKISS, P. 2011. Climate change impacts and adaptation in cities: a review of the literature. *Climatic Change,* 104**,** 13-49.

HUNTER, W. C. 2011. Rukai indigenous tourism: Representations, cultural identity and Q method. *Tourism Management,* 32**,** 335-348.

HUQ, S., AYRES, J., OKUBO, Y., MICHAELOWA, A., BEHRENS, A. & KLEIN, R. J. T. 2008. Streamlining adaptation to climate change into development projects at the national and local level. In European Parliament, Financing climate change policies in developing countries. International Institute for Environment and Development

HYSING, E. 2009. Greening Transport—Explaining Urban Transport Policy Change. *Journal of Environmental Policy & Planning,* 11**,** 243-261.

ICLEI 2011. Resilient Cities 2011: Congress Report. Bonn, Germany.

INGOLD, K. 2011. Network Structures within Policy Processes: Coalitions, Power, and Brokerage in Swiss Climate Policy. *Policy Studies Journal,* 39**,** 435-459.

INTURRI, G. & IGNACCOLO, M. 2011. The Role of Transport in Mitigation and Adaptation to Climate Change Impacts in Urban Areas. *In:* OTTO-ZIMMERMANN, K. (ed.) *Resilient Cities.* Springer Netherlands.

IPCC 1990. *IPCC First Assessment Report (FAR)*.

IPCC 1996. *Climate change 1995: The science of climate change: contribution of working group I to the second assessment report of the Intergovernmental Panel on Climate Change*, Cambridge University Press.

IPCC 2001. Climate change 2001: impacts, adaptation, and vulnerability: contribution of Working Group II to the third assessment report of the Intergovernmental Panel on Climate Change. *In:* MCCARTHY, J. J. (ed.). Cambridge University Press.

IPCC 2007a. *Climate change 2007 : impacts, adaptation and vulnerability : working group II contribution to the fourth assessment report of the IPCC intergovernmental panel on climate change,* New York, Cambridge University Press.

IPCC 2007b. Summary for Policymakers. *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)].* Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

IPCC 2012. Summary for Policymakers. *In:* BARROS, V., STOCKER, T. F., QIN, D., DOKKEN, D. J., EBI, K. L., MASTRANDREA, M. D., MACH, K. J., PLATTNER, G.-K., ALLEN, S. K., TIGNOR, M. & MIDGLEY, P. M. (eds.) *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation: A Special Report of Working GroupsI and II of the Intergovernmental Panel on Climate Change.* Cambridge, UK, and New York, NY, USA: Cambridge University Press.

IPCC 2013. Climate Change 2013, The Physical Science Basis, Summary for Policymakers. *In:* STOCKER, T. F., QIN, D., PLATTNER, G.-K., TIGNOR, M. M. B., ALLEN, S. K., BOSCHUNG, J., NAUELS, A., XIA, Y., BEX, V. & MIDGLEY, P. M. (eds.) *Fifth Assessment Report (AR5).* Intergovernmental Panel on Climate Change.

IPCC 2014a. Climate change 2014: impacts, adaptation, and vulnerability. *In:* FIELD, C. B., BARROS, V. R., MACH, K. & MASTRANDREA, M. (eds.) *Working Group II Contribution to the IPCC 5th Assessment Report-Technical Summary.*

IPCC 2014b. Summary for policy makers. *In:* FIELD, C., BARROS, V. & MASTRANDREA, M. (eds.) *Climate change 2014: Impacts, adaptation, and vulnerability.*: Technical report, IPCC.

IPDET 2001. Module 8: Data Collection Methods. *International Program for Development Evaluation Training (Handbook).*

ISNI 2011. Draft Investment Strategy for Northern Ireland 2011-21. NI-Executive, the First Minister and the deputy First Minister.

ISOARD, S. 2011. Perspectives on Adaptation to Climate Change in Europe Climate Change Adaptation in Developed Nations. *In:* FORD, J. D. & BERRANG-FORD, L. (eds.). Springer Netherlands.

ISON, S. & RYE, T. 2003. Lessons from travel planning and road user charging for policy-making: through imperfection to implementation. *Transport Policy,* 10**,** 223-233.

JAROSZWESKI, D., CHAPMAN, L. & PETTS, J. 2010. Assessing the potential impact of climate change on transportation: the need for an interdisciplinary approach. *Journal of Transport Geography,* 18**,** 331-335.

JAROSZWESKI, D., HOOPER, E. & CHAPMAN, L. 2014. The impact of climate change on urban transport resilience in a changing world. *Progress in Physical Geography,* 38, 448-463.

JEDELOO, S., VAN STAA, A., LATOUR, J. M. & VAN EXEL, N. J. 2010. Preferences for health care and self-management among Dutch adolescents with chronic conditions: a Q-methodological investigation. *Int J Nurs Stud,* 47, 593-603.

JENKINS-SMITH, H. C. & SABATIER, P. 2003. The study of public policy processes. *In:* LEE, P. R. & ESTES, C. L. (eds.) *The Nation's Health.* Mississauga: Jones and Bartlett.

JEPSON, W., BRANNSTROM, C. & PERSONS, N. 2012. "We Don't Take the Pledge": Environmentality and environmental skepticism at the epicenter of US wind energy development. *Geoforum,* 43, 851-863.

JERNECK, A. & OLSSON, L. 2008. Adaptation and the poor: development, resilience and transition. *Climate Policy,* 8, 170-182.

JONKER, R. & VOLGENANT, T. 1986. Improving the Hungarian assignment algorithm. *Operations Research Letters,* 5, 171-175.

JUHOLA, S. & WESTERHOFF, L. 2011. Challenges of adaptation to climate change across multiple scales: a case study of network governance in two European countries. *Environmental Science & Policy,* 14, 239-247.

KAMPEN, J. & TAMÁS, P. 2013. Overly ambitious: contributions and current status of Q methodology. *Quality & Quantity*, 1-18.

KANE, L. & DEL MISTRO, R. 2003. Changes in transport planning policy: Changes in transport planning methodology? *Transportation,* 30, 113-131.

KAPLOWITZ, M. D. & HOEHN, J. P. 2001. Do focus groups and individual interviews reveal the same information for natural resource valuation? *Ecological Economics,* 36, 237-247.

KARLIK, B. & OLGAC, A. V. 2011. Performance analysis of various activation functions in generalized MLP architectures of neural networks. *International Journal of Artificial Intelligence and Expert Systems,* 1, 111-122.

KAROLY, D. J. 2014. Climate change: Human-induced rainfall changes. *Nature Geosci,* 7, 551-552.

KEELE, R. 2010. *Nursing Research and Evidence-Based Practice*, Jones & Bartlett Learning.

KERN, K. & ALBER, G. Governing climate change in cities: modes of urban climate governance in multi-level systems. OECD Conference on Competitive Cities and Climate Change, 9-10 October 2008 Milan, Italy. 171-196.

KHAILANI, D. K. & PERERA, R. 2013. Mainstreaming disaster resilience attributes in local development plans for the adaptation to climate change induced flooding: A study based on the local plan of Shah Alam City, Malaysia. *Land Use Policy,* 30**,** 615-627.

KHAN, F. I. & MUNAWAR, S. 2011. Institutional Arrangements for Climate Change in Pakistan *In:* RAMAY, S. A. (ed.). Sustainable Development Policy Institute

KHATTAK, A. J. & DE PALMA, A. 1997. The impact of adverse weather conditions on the propensity to change travel decisions: A survey of Brussels commuters. *Transportation Research Part A: Policy and Practice,* 31**,** 181-203.

KLEIN, R. J., SCHIPPER, E. L. F. & DESSAI, S. 2005. Integrating mitigation and adaptation into climate and development policy: three research questions. *Environmental Science & Policy,* 8**,** 579-588.

KLEIN, R. J. T., NICHOLLS, R. J. & THOMALLA, F. 2003. Resilience to natural hazards: How useful is this concept? *Global Environmental Change Part B: Environmental Hazards,* 5**,** 35-45.

KLEINOSKY, L., YARNAL, B. & FISHER, A. 2007. Vulnerability of Hampton Roads, Virginia to Storm-Surge Flooding and Sea-Level Rise. *Natural Hazards,* 40**,** 43-70.

KNIELING, J. & LEAL FILHO, W. 2013. Climate Change Governance: The Challenge for Politics and Public Administration, Enterprises and Civil Society. *In:* KNIELING, J. & LEAL FILHO, W. (eds.) *Climate Change Governance.* Springer Berlin Heidelberg.

KOENIG, U. & ABEGG, B. 1997. Impacts of climate change on winter tourism in the Swiss Alps. *Journal of sustainable tourism,* 5**,** 46-58.

KOETSE, M. J. & RIETVELD, P. 2009. The impact of climate change and weather on transport: An overview of empirical findings. *Transportation Research Part D: Transport and Environment,* 14**,** 205-221.

KOETSE, M. J. & RIETVELD, P. 2012. Adaptation to Climate Change in the Transport Sector. *Transport Reviews,* 32**,** 267-286.

KRISTENSEN, E. & JAKOBSEN, E. B. 2011. Danish dairy farmers' perception of biosecurity. *Preventive Veterinary Medicine,* 99**,** 122-129.

KRUEGER, R. A. & CASEY, M. A. 2001. Designing and Conducting Focus Group Interviews. *In:* KRUEGER, R. A., CASEY, M. A., DONNER, J., KIRSCH, S. & MAACK, J. N. (eds.) *Social Analysis Selected Tools and Techniques.*

KUHN, H. W. 1955. The Hungarian method for the assignment problem. *Naval research logistics quarterly,* 2**,** 83-97.

LADRECH, R. 2011. Social Democratic Parties and the Challenge of Climate Change Policy. *the 12th Biennial Conference of the European Union Studies Association.* Boston.

LANG, C. 2014. Do weather fluctuations cause people to seek information about climate change? *Climatic Change,* 125**,** 291-303.

LANG, T. 2011. Urban Resilience and New Institutional Theory – A Happy Couple for Urban and Regional Studies? . *In:* MÜLLER, B. (ed.) *German Annual of Spatial Research and Policy 2010.* Springer Berlin Heidelberg.

LANGLAIS, R. 2009. A Climate of Planning: Swedish Municipal Responses to Climate Change. *In:* DAVOUDI, S., CRAWFORD, J. & MEHMOOD, A. (eds.) *Planning for Climate Change: Strategies for Mitigation and Adaptation for Spatial Planners.* London: Earthscan.

LANSING, D. M. 2013. Not all baselines are created equal: A Q methodology analysis of stakeholder perspectives of additionality in a carbon forestry offset project in Costa Rica. *Global Environmental Change,* 23**,** 654-663.

LARSEN, R. K., SWARTLING, Å. G., POWELL, N., MAY, B., PLUMMER, R., SIMONSSON, L. & OSBECK, M. 2012. A framework for facilitating dialogue between policy planners and local climate change adaptation professionals: Cases from Sweden, Canada and Indonesia. *Environmental Science & Policy,* 23**,** 12-23.

LAWRENCE, S., GILES, C. L. & TSOI, A. C. Lessons in neural network training: Overfitting may be harder than expected. Fourteenth National Conference on Artificial Intelligence, 1997 Menlo Park, California. CiteseerX, 540-545.

LE QUESNE, T., KENDY, E. & WESTON, D. 2010. The Implementation Challenge. *Taking stock of government policies to protect and restore environmental flows.*

LEE, C., REY, T., MENTELE, J. & GARVER, M. 2005. Structured neural network techniques for modeling loyalty and profitability. *Proceedings of the Thirtieth Annual SAS Users Group International Conference.* Cary, North Carolina, USA: SAS Institute Inc.

LEECH, N. L. & ONWUEGBUZIE, A. J. 2007. An array of qualitative data analysis tools: A call for data analysis triangulation. *School Psychology Quarterly,* 22**,** 557-584.

LEGACY, C., CURTIS, C. & STURUP, S. 2012. Is there a good governance model for the delivery of contemporary transport policy and practice? An examination of Melbourne and Perth. *Transport Policy,* 19**,** 8-16.

LEGENDRE, P. 2005. Species associations: the Kendall coefficient of concordance revisited. *Journal of Agricultural, Biological, and Environmental Statistics,* 10**,** 226-245.

LEGISLATION 1999. *Strategic Planning (Northern Ireland) Order 1999: Northern Ireland*, Stationery Office, The.

LEGISLATION 2009. Climate Change Act 2009 (Scotland). *In:* GOVERNMENT, T. S. (ed.).

LEISEROWITZ, A. A. 2004. Day After Tomorrow: Study of Climate Change Risk Perception. *Environment: Science and Policy for Sustainable Development,* 46, 22-39.

LEONARD, S., PARSONS, M., OLAWSKY, K. & KOFOD, F. The role of culture and traditional knowledge in climate change adaptation: Insights from East Kimberley, Australia. *Global Environmental Change*.

LINDBLOM, C. E. 1959. The science of "muddling through". *Public administration review*, 79-88.

LIPSKY, M. 1971. Street-Level Bureaucracy and the Analysis of Urban Reform. *Urban Affairs Review,* 6, 391-409.

LIPSKY, M. 1980. *Street-Level Bureaucracy: The Dilemmas of the Individual in Public Service*, Russell Sage Foundation.

LIPSKY, M. 2010. *Street-level bureaucracy: Dilemmas of the individual in public services*, Russell Sage Foundation Publications.

LOBELL, D. B., BALDOS, U. L. C. & HERTEL, T. W. 2013. Climate adaptation as mitigation: the case of agricultural investments. *Environmental Research Letters,* 8, 1-12.

LOCKWOOD, M. 2011. Does the framing of climate policies make a difference to public support? Evidence from UK marginal constituencies. *Climate Policy,* 11, 1097-1112.

LUND, D. H., SEHESTED, K., HELLESEN, T. & NELLEMANN, V. 2012. Climate change adaptation in Denmark: enhancement through collaboration and meta-governance? *Local Environment,* 17, 613-628.

MACK, N., WOODSONG, C., MACQUEEN, K., GUEST, G. & NAMELY, E. 2005. *Qualitative research methods: A data collector's field guide*, Family Health International.

MAHADEVAN, S. 1997. Monte Carlo Simulation. *In:* CRUSE, T. A. (ed.) *Reliability-Based Mechanical Design (Volume 108 of Mechanical Engineering).* CRC Press.

MALIA, C. & BENNETT, M. I. 2011. What Influences Patients' Decisions on Artificial Hydration at the End of Life? A Q-Methodology Study. *Journal of Pain and Symptom Management,* 42, 192-201.

MALVERN, D. & SKIDMORE, D. 2001. Measuring Value Consensus Among Teachers in Respect of Special Educational Needs. *Educational Studies,* 27**,** 17-29.

MANASFI, N. & GREENHALGH, E. 2011. Finding the Balance: Challenges and Opportunities for Climate Change Adaptation at Different Levels of English Local Government Resilient Cities. *In:* OTTO-ZIMMERMANN, K. (ed.). Springer Netherlands.

MARSDEN, G. & MAY, A. D. 2006. Do institutional arrangements make a difference to transport policy and implementation? Lessons for Britain. *Environment and Planning C: Government and Policy,* 24**,** 771-789.

MARSDEN, G. & RYE, T. 2010. The governance of transport and climate change. *Journal of Transport Geography,* 18**,** 669-678.

MARSHALL, G. 2005. The purpose, design and administration of a questionnaire for data collection. *Radiography,* 11**,** 131-136.

MATLAND, R. E. 1995. Synthesizing the implementation literature: The ambiguity-conflict model of policy implementation. *Journal of public administration research and theory,* 5**,** 145-174.

MAZMANIAN, D. A., JUREWITZ, J. & NELSON, H. T. 2013. The Paradox of "Acting Globally While Thinking Locally": Discordance in Climate Change Adaption Policy. *The Journal of Environment & Development*.

MBENG, L. O., PHILLIPS, P. S. & FAIRWEATHER, R. 2009. Developing sustainable waste management practice: application of Q methodology to construct new strategy component in Limbe–Cameroon. *The Open Waste Management Journal,* 2**,** 27-36.

MCCULLOCH, W. & PITTS, W. 1943. A logical calculus of the ideas immanent in nervous activity. *The bulletin of mathematical biophysics,* 5**,** 115-133.

MCLAFFERTY, I. 2004. Focus group interviews as a data collecting strategy. *Journal of Advanced Nursing,* 48**,** 187-194.

MCLAUGHLIN, C. & KRANTZBERG, G. 2011. An appraisal of policy implementation deficits in the Great Lakes. *Journal of Great Lakes Research,* 37**,** 390-396.

MEADOWCROFT, J. 2009. Climate Change Governance: A paper contributing to the 2010 World Bank World Development Report. The World Bank - World Development Report Team.

MEASHAM, T. G., PRESTON, B., SMITH, T., BROOKE, C., GORDDARD, R., WITHYCOMBE, G. & MORRISON, C. 2011. Adapting to climate change through local municipal planning: barriers and challenges. *Mitigation and Adaptation Strategies for Global Change,* 16**,** 889-909.

MEIJERINK, S. 2005. Understanding policy stability and change. the interplay of advocacy coalitions and epistemic communities, windows of opportunity, and Dutch coastal flooding policy 1945–2003. *Journal of European Public Policy,* 12**,** 1060-1077.

METAG, J., SCHÄFER, M. S., FÜCHSLIN, T., BARSUHN, T. & KLEINEN-VON KÖNIGSLÖW, K. 2016. Perceptions of Climate Change Imagery: Evoked Salience and Self-Efficacy in Germany, Switzerland, and Austria. *Science Communication,* 38**,** 197-227.

METER, D. S. V. & HORN, C. E. V. 1975. The Policy Implementation Process : A Conceptual Framework. *Administration & Society,* 6**,** 445-488.

MIMURA, N. 2013. Wise adaptation to climate change. *Climate Adaptation Futures.* John Wiley & Sons.

MITSAKIS, E., PAPANIKOLAOU, A., AYFADOPOULOU, G., SALANOVA, J., DOLL, C., GIANNOPOULOS, G. & ZEREFOS, C. 2014. An integrated framework for linking climate change impacts to emergency adaptation strategies for transport networks. *European Transport Research Review,* 6**,** 103-111.

MORECROFT, C., CANTRILL, J. & TULLY, M. P. 2006. Individual patient's preferences for hypertension management: A Q-methodological approach. *Patient Education and Counseling,* 61**,** 354-362.

MORTIME, C. 2010. Assessing urban resilience. University of Auckland.

MOSER, S. C. & EKSTROM, J. A. 2010. A framework to diagnose barriers to climate change adaptation. *Proceedings of the National Academy of Sciences,* 107**,** 22026-22031.

MÜLLER, B. 2011. Urban and Regional Resilience – A New Catchword or a Consistent Concept for Research and Practice? *In:* MÜLLER, B. (ed.) *German Annual of Spatial Research and Policy 2010.* Springer Berlin Heidelberg.

NANKERVIS, M. 1999. The effect of weather and climate on bicycle commuting. *Transportation Research Part A: Policy and Practice,* 33**,** 417-431.

NELLTHORP, J. & MACKIE, P. J. 2000. The UK Roads Review—a hedonic model of decision making. *Transport Policy,* 7**,** 127-138.

NELSON, D. R., ADGER, W. N. & BROWN, K. 2007. Adaptation to Environmental Change: Contributions of a Resilience Framework. *Annual Review of Environment and Resources,* 32**,** 395-419.

NEUMAN, W. L. 2007. *Basics of social research : qualitative and quantitative approaches,* Boston, MA. , Pearson.

NEUMAYER, E. 2007. A missed opportunity: The Stern Review on climate change fails to tackle the issue of non-substitutable loss of natural capital. *Global Environmental Change,* 17**,** 297-301.

NEWIG, J. & FRITSCH, O. 2009. Environmental governance: participatory, multi-level – and effective? *Environmental Policy and Governance,* 19**,** 197-214.

NI-ASSEMBLY 2012. Local Government Reform Past and Present. Belfast: Research and Information Service.

NI-DIRECT. 2016. *Changes to government departments* [Online]. Available: https://www.nidirect.gov.uk/articles/changes-government-departments [Accessed].

NI-DIRECT. 2017. *Local Councils* [Online]. Available: https://www.nidirect.gov.uk/articles/local-councils [Accessed 11/06/2017].

NI-EXECUTIVE 2011. Programme for Government 2011-15: Building a Better Future. Belfast, OFMDFM.

NIEDERBERGER, A. A. 2005. The Swiss Climate Penny: An innovative approach to transport sector emissions. *Transport Policy,* 12**,** 303-313.

NIKRAFTAR, T. 2013. The conceptions about managing coordination in Iranian governmental machinery: a Q methodology study. *Quality & Quantity,* 47**,** 2577-2596.

NILSSON, A. E., GERGER SWARTLING, Å. & ECKERBERG, K. 2012. Knowledge for local climate change adaptation in Sweden: challenges of multilevel governance. *Local Environment,* 17**,** 751-767.

NOLAND, R. B. & LEM, L. L. 2002. A review of the evidence for induced travel and changes in transportation and environmental policy in the US and the UK. *Transportation Research Part D: Transport and Environment,* 7**,** 1-26.

O'TOOLE, L. J. 1986. Policy Recommendations for Multi-Actor Implementation: An Assessment of the Field. *Journal of Public Policy,* 6**,** 181-210.

O'TOOLE, L. J. 2000. Research on policy implementation: Assessment and prospects. *Journal of public administration research and theory,* 10**,** 263-288.

OCKWELL, D. 2008. 'Opening up' policy to reflexive appraisal: a role for Q Methodology? A case study of fire management in Cape York, Australia. *Policy Sciences,* 41**,** 263-292.

OLESEN, J. E. & BINDI, M. 2002. Consequences of climate change for European agricultural productivity, land use and policy. *European Journal of Agronomy,* 16**,** 239-262.

ONWUEGBUZIE, A. J., DICKINSON, W. B., LEECH, N. L. & ZORAN, A. G. 2009. A qualitative framework for collecting and analyzing data in focus group research. *International Journal of Qualitative Methods,* 8**,** 1-21.

OSTROM, E. 2007. Institutional rational choice: an assessment of the institutional analysis and development framework. *In:* SABATIER, P. (ed.) *Theories of the Policy Process.* Cambridge: Westview Press.

PAAVOLA, J. & ADGER, W. N. 2006. Fair adaptation to climate change. *Ecological Economics,* 56**,** 594-609.

PANCHAL, G., GANATRA, A., KOSTA, Y. & PANCHAL, D. 2010. Searching Most Efficient Neural Network Architecture Using Akaike's Information Criterion (AIC). *International Journal of Computer Applications,* 1**,** 41-44.

PARLIAMENT 1967. Transport Act (Northern Ireland) 1967.

PARLIAMENT 1998. Northern Ireland Act 1998

PARLIAMENT 2005. Transport (Scotland) Act 2005

PARLIAMENT 2006. Government of Wales Act 2006.

PARLIAMENT 2008. Climate Change Act 2008. London: The Stationery Office Limited.

PARLIAMENT 2010. Resilience of UK Infrastructure. *In:* HOUSE OF PARLIAMENT, P. O. O. S. A. T. P. (ed.).

PARLIMANT 2008. Planning Act 2008: Chapter 29. Stationery Office.

PARRY, M. L. 2009. *Assessing the Costs of Adaptation to Climate Change: A Review of the UNFCCC and other recent estimates*, Iied.

PARSONS, D. W. 1995. *Public policy : an introduction to the theory and practice of policy analysis,* Cheltenham Aldershot : Edward Elgar.

PAUDEL, N. R. 2009. A Critical Account of Policy Implementation Theories: Status and Reconsideration. *Nepalese Journal of Public Policy and Governance,* xxv**,** 36-54.

PELLING, M. & HIGH, C. 2005. Understanding adaptation: What can social capital offer assessments of adaptive capacity? *Global Environmental Change,* 15**,** 308-319.

PEMBERTON, S. 2000. Institutional governance, scale and transport policy – lessons from Tyne and Wear. *Journal of Transport Geography,* 8**,** 295-308.

PENNING-ROWSELL, E., PRIEST, S., PARKER, D., MORRIS, J., TUNSTALL, S., VIAVATTENE, C., CHATTERTON, J. & OWEN, D. 2014. *Flood and Coastal Erosion Risk Management: A Manual for Economic Appraisal*, Taylor & Francis.

PFG 2012. Programme for Government 2011 - 2015. the First Minister and deputy First Minister, Programme for Government Team.

PIELKE JR, R. 2007. Mistreatment of the economic impacts of extreme events in the Stern Review Report on the Economics of Climate Change. *Global Environmental Change,* 17**,** 302-310.

PIELKE JR, R. A. 1998. Rethinking the role of adaptation in climate policy. *Global Environmental Change,* 8**,** 159-170.

PILLI-SIHVOLA, K., NURMI, V., PERRELS, A., HARJANNE, A., BÖSCH, P. & CIARI, F. 2016. Innovations in weather services as a crucial building block for climate change adaptation in road transport. *EJTIR,* 16**,** 150-173.

PRASAD, N., RANGHIERI, F., SHAH, F., TROHANIS, Z., KESSLER, E. & SINHA, R. 2009. *Climate resilient cities : a primer on reducing vulnerabilities to disasters,* Washington, D.C., World Bank.

PRESSMAN, J. L. & WILDAVSKY, A. B. 1973. *Implementation : how great expectations in Washington are dashed in Oakland : or, Why it's amazing that Federal programs work at all, this being a saga of the Economic Development Administration as told by two sympathetic observers who seek to build morals on a foundation of ruined hopes,* Berkeley, University of California Press.

RAJAGOPALAN, N. & RASHEED, A. M. A. 1995. Incremental Models of Policy Formulation and Non-incremental Changes: Critical Review and Synthesis1. *British Journal of Management,* 6**,** 289-302.

RAJÉ, F. 2007. Using Q methodology to develop more perceptive insights on transport and social inclusion. *Transport Policy,* 14**,** 467-477.

RATTANACHOT, W., WANG, Y., CHONG, D. & SUWANSAWAS, S. 2015. Adaptation strategies of transport infrastructures to global climate change. *Transport Policy,* 41**,** 159-166.

RAYMOND, C. M. & ROBINSON, G. M. 2013. Factors affecting rural landholders' adaptation to climate change: Insights from formal institutions and communities of practice. *Global Environmental Change,* 23**,** 103-114.

RESALLIANCE 2007. Urban Resilience: Research Prospectus: A Resilience Alliance Initiative for Transitioning Urban Systems towards Sustainable Futures. Canberra: Resilience Alliance.

RIPLEY, B. D. 2007. *Pattern Recognition and Neural Networks*, Cambridge University Press.

RODRIGUEZ-PIÑEROS, S., FOCHT, W., LEWIS, D. & MONTGOMERY, D. 2012. Incorporating Values into Community-Scale Sustainable Forest Management Plans: An Application of Q Methodology. *Small-Scale Forestry,* 11**,** 167-183.

SABATIER, P. A. 1986. Top-Down and Bottom-Up Approaches to Implementation Research: a Critical Analysis and Suggested Synthesis. *Journal of Public Policy,* 6, 21-48.

SABATIER, P. A. 1991. Toward better theories of the policy process. *PS: Political Science and Politics,* 24, 147-156.

SABATIER, P. A. 1998. The advocacy coalition framework: revisions and relevance for Europe. *Journal of European Public Policy,* 5, 98-130.

SABATIER, P. A. 1999. *Theories Of The Policy Process*, Westview Press.

SABATIER, P. A. 2007. The need for better theories. *In:* SABATIER, P. A. (ed.) *Theories of the policy process.* Boulder: Westview Press.

SABIR, M., KOETSE, M. & RIETVELD, P. 2008. The impact of weather conditions on mode choice decisions: empirical evidence for the Netherlands. *Forthcoming as Tinbergen Institute Discussion Paper. VU University, Amsterdam*.

SABIR, M., OMMEREN, J., KOETSE, M. & RIETVELD, P. 2011. Adverse Weather and Commuting Speed. *Networks and Spatial Economics,* 11, 701-712.

SAETREN, H. 2005. Facts and Myths about Research on Public Policy Implementation: Out-of-Fashion, Allegedly Dead, But Still Very Much Alive and Relevant. *Policy Studies Journal,* 33, 559-582.

SAUNDERS, M., LEWIS, P. & THORNHILL, A. 2009. *Research methods for business students,* Harlow (Essex); London; New York, Pearson Education ; Financial Times : Prentice Hall.

SCCD. 2012. *Scotland's Climate Change Declaration: Annual Reports* [Online]. Available: http://climatechange.sustainable-scotland.net/index.asp?pg=3 [Accessed 17 May 2012].

SCHLAGER, E. & BLOMQUIST, W. 1996. A Comparison of Three Emerging Theories of the Policy Process. *Political Research Quarterly,* 49, 651-672.

SCHMIDT, L., PRISTA, P., SARAIVA, T., O'RIORDAN, T. & GOMES, C. 2013. Adapting governance for coastal change in Portugal. *Land Use Policy,* 31, 314-325.

SCHOFIELD, J. & SAUSMAN, C. 2004. Symposium on Implementing Public Policy: Learning from Theory and Practice. *Public Administration,* 82, 235-248.

SCOTLAND 2009. Scotland's Climate Change Adaptation Framework. *In:* GOVERNMENT, S. (ed.). Edinburgh: Scottish Executive.

SCOTLAND 2010. Scottish Planning Policy. *In:* GOVERNMENT, T. S. (ed.).

SCOTLAND 2011. Scotland's Climate Change Adaptation Framework: Transport Sector Action Plan

SCOTTISH-EXECUTIVE 2000. Scottish Climate Change Programme. *In:* TEAM, S. E. C. C. (ed.). Edinburgh: Scottish Executive.

SCOTTISH-EXECUTIVE 2006. Scotland's National Transport Strategy. Scottish Executive.

SEWTA 2010. South East Wales Transport Alliance: Regional Transport Plan.

SHAW, C., HALES, S., HOWDEN-CHAPMAN, P. & EDWARDS, R. 2014. Health co-benefits of climate change mitigation policies in the transport sector. *Nature Clim. Change,* 4**,** 427-433.

SHAW, J., MACKINNON, D. & DOCHERTY, I. 2009. Divergence or convergence? Devolution and transport policy in the United Kingdom. *Environment and Planning C: Government & Policy,* 27**,** 546-567.

SHAW, K. & THEOBALD, K. 2011. Resilient local government and climate change interventions in the UK. *Local Environment,* 16**,** 1-15.

SIMONSSON, L., SWARTLING, Å. G., ANDRÉ, K., WALLGREN, O. & KLEIN, R. J. T. 2011. Perceptions of Risk and Limits to Climate Change Adaptation: Case Studies of Two Swedish Urban Regions Climate Change Adaptation in Developed Nations. *In:* FORD, J. D. & BERRANG-FORD, L. (eds.). Springer Netherlands.

SMIT, B. & PILIFOSOVA, O. 2003. Adaptation to climate change in the context of sustainable development and equity. *Sustainable Development,* 8**,** 9.

SMITH, T., BROOKE, C., MEASHAM, T., PRESTON, B., GORDDARD, R., WITHYCOMBE, G., BEVERIDGE, B. & MORRISON, C. 2009. Case studies of adaptive capacity: systems approach to regional climate change adaptation strategies. *Sydney Coastal Councils Group, Sydney Australia*.

SPERLING, D. & CANNON, J. S. 2010. *Driving Climate Change: Cutting Carbon from Transportation*, Elsevier Science.

SRIVASTAVA, A. & THOMSON, S. B. 2009. Framework analysis: a qualitative methodology for applied policy research. *Journal of Administration & Governance,* 4**,** 72-79.

STAFFORD, I. 2010. The regional governance of transport policy in Wales: towards institutional decongestion? Available: http://www.psa.ac.uk/spgrp/4/2010/Ppr/BaCTPSGC2_StaffordIan_StaffordPSA2010.pdf [Accessed 18 May 2012].

STEPHENSON, W. 1935. Correlationg persons instead of tests. *Journal of Personality,* 4**,** 17-24.

STERN, N. H. 2007. *The economics of climate change: the Stern review*, Cambridge University Press.

STOKER, G. 1998. Governance as theory: five propositions. *International Social Science Journal,* 50, 17-28.

STRAUCH, R. L., RAYMOND, C. L., ROCHEFORT, R. M., HAMLET, A. F. & LAUVER, C. 2015. Adapting transportation to climate change on federal lands in Washington State, U.S.A. *Climatic Change,* 130, 185-199.

SUAREZ, P., ANDERSON, W., MAHAL, V. & LAKSHMANAN, T. R. 2005. Impacts of flooding and climate change on urban transportation: A systemwide performance assessment of the Boston Metro Area. *Transportation Research Part D: Transport and Environment,* 10, 231-244.

SUGIURA, N. 1978. Further analysts of the data by akaike' s information criterion and the finite corrections. *Communications in Statistics - Theory and Methods,* 7, 13-26.

SUNG, K. 2011. Exploring Wisdom in the Korean Elderly: A Q Methodology Study. *Asian Nursing Research,* 5, 128-140.

SWWITCH n.d. Progress in Partnership - The Regional Transport Plan for South West Wales 2010-2015.

SZARKA, J. 2004. Wind power, discourse coalitions and climate change: breaking the stalemate? *European Environment,* 14, 317-330.

TAITH 2009. North Wales Regional Transport Plan.

TAKEUCHI, K. 1976. Distribution of informational statistics and a criterion of model fitting. *Suri-Kagaku (Mathematic Sciences),* 153, 12–18.

TANNER, T., MITCHELL, T., POLACK, E. & GUENTHER, B. 2009. Urban governance for adaptation: assessing climate change resilience in ten Asian cities. *IDS Working Papers,* 2009, 01-47.

TAVASSZY, L., BOLLINGER, L. A. & DIJKEMA, G. P. 2016. Editorial: Special Issue on Climate Adaptation of Infrastructure Networks. *EJTIR,* 16, 95-97.

TEN KLOOSTER, P. M., VISSER, M. & DE JONG, M. D. T. 2008. Comparing two image research instruments: The Q-sort method versus the Likert attitude questionnaire. *Food Quality and Preference,* 19, 511-518.

TERMEER, C., BIESBROEK, R. & VAN DEN BRINK, M. 2011. Institutions for Adaptation to Climate Change: Comparing National Adaptation Strategies in Europe. *European Political Science,* 11, 41.

TERMEER, C., DEWULF, A. & BREEMAN, G. 2013. Governance of Wicked Climate Adaptation Problems. *In:* KNIELING, J. & LEAL FILHO, W. (eds.) *Climate Change Governance.* Springer Berlin Heidelberg.

THOMAS, J., THISTLETHWAITE, G., MACCARTHY, J., PEARSON, B., MURRELLS, T., PANG, Y., PASSANT, N., WEBB, N., CONOLLY, C., CARDENAS, L., MALCOLM,

H. & THOMSON, A. 2011. Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 - 2009. Didcot: Department of Energy and Climate Change, The Scottish Government, The Welsh Government, The Northern Ireland Department of Environment.

THOMPSON, B., FRANKIEWICZ, R. G. & WARD, G. R. 1983. Cross-technique validation of attitude measures. *Operant Subjectivity*.

THORNES, J. E. 2005. Snow and road chaos in Birmingham on 28 January 2004. *Weather,* 60**,** 146-149.

TIESDELL, S. A. 1999. *The development & implementation of housing action trust policy.* PhD eThesis, University of Nottingham.

TOMPKINS, E., BOYD, E., NICHOLSON-COLE, S., WEATHERHEAD, K., ARNELL, N. & ADGER, W. 2009. An Inventory of Adaptation to climate change in the UK: challenges and findings. *Tyndall Centre for Climate Change Research Working Paper,* 135**,** 133.

TOMPKINS, E. L., ADGER, W. N., BOYD, E., NICHOLSON-COLE, S., WEATHERHEAD, K. & ARNELL, N. 2010. Observed adaptation to climate change: UK evidence of transition to a well-adapting society. *Global Environmental Change,* 20**,** 627-635.

TRACC 2008. Regional Transport Plan: Habitats Regulations Assessment.

TRB 2008. *Potential Impacts Of Climate Change On U.S. Transportation*, Transportation Research Board, National Research Council, Committee on Climate Change.

TU, J. V. 1996. Advantages and disadvantages of using artificial neural networks versus logistic regression for predicting medical outcomes. *Journal of Clinical Epidemiology,* 49**,** 1225-31.

TURHAN, E. 2016. Value-based adaptation to climate change and divergent developmentalisms in Turkish agriculture. *Ecological Economics,* 121**,** 140-148.

TURNBULL, K. F., NORMAN, M. R., BECKETT, J. G., CARLSON, P., KAZMIEROWSKI, T. J., KNIPLING, R. R., KROSS, M. S., KUSSY, E. V. A., MANDLE, P. B., PERL, A. D., SILKUNAS, S., SWAN, P. F. & ZMUD, J. P. 2011. Adapting Transportation to the Impacts of Climate Change: State of the Practice 2011. Texas: Transportation Research Board (TRB).

UN-HABITAT 2011. Cities and Climate Change: Global Report on Human Settlements 2011. Washington, DC: United Nations Human Settlements Programme (UN-Habitat).

UN 2007. World Urbanization Prospects. *The 2007 Revision Population Database.* United Nations Population Division.

UNESCAP. 2011. *What is good governance?* [Online]. United Nations Economic and Social Commission for Asia and the Pacific. Available: http://www.unescap.org/huset/gg/governance.htm [Accessed 12 November, 2011 2011].

UNESCAP 2012. Green Growth, Resources and Resilience Environmental Sustainability in Asia and the Pacific Bangkok: United Nations and Asian Development Bank publication.

UNFCCC. 1992. *Ahead to Article 4 : Commitments* [Online]. United Nations Framework Convention on Climate Change. Available: http://unfccc.int/essential_background/convention/background/items/1362.php [Accessed 10 May 2012].

UNFCCC 1997. United Nations Framework Convention on Climate Change. *Kyoto Protocol, Kyoto,* 19.

URQUHART, J., COURTNEY, P. & SLEE, B. 2012. Private woodland owners' perspectives on multifunctionality in English woodlands. *Journal of Rural Studies,* 28**,** 95-106.

URWIN, K. & JORDAN, A. 2008. Does public policy support or undermine climate change adaptation? Exploring policy interplay across different scales of governance. *Global Environmental Change,* 18**,** 180-191.

VALENTA, A. L. & WIGGER, U. 1997. Q-methodology: Definition and application in health care informatics. *Journal of the American Medical Informatics Association,* 4**,** 501-510.

VAN AALST, M. K., CANNON, T. & BURTON, I. 2008. Community level adaptation to climate change: The potential role of participatory community risk assessment. *Global Environmental Change,* 18**,** 165-179.

VAN STADEN, M. & MUSCO, F. 2010. Local Action – Planning and Implementation. *In:* VAN STADEN, M. & MUSCO, F. (eds.) *Local Governments and Climate Change.* Springer Netherlands.

VIGNOLA, R., KLINSKY, S., TAM, J. & MCDANIELS, T. 2013. Public perception, knowledge and policy support for mitigation and adaption to Climate Change in Costa Rica: Comparisons with North American and European studies. *Mitigation and Adaptation Strategies for Global Change,* 18**,** 303-323.

VROLIJKS, L., SPATAFORE, A. & MITTAL, A. S. 2011. Comparative Research on the Adaptation Strategies of Ten Urban Climate Plans

Resilient Cities. *In:* OTTO-ZIMMERMANN, K. (ed.). Springer Netherlands.

WALES 2008a. One Wales: Connecting the Nation, The Wales Transport Strategy. *In:* GOVERNMENT, W. A. (ed.).

WALES 2008b. Welsh Transport Planning and Appraisal Guidance: WelTAG.

WALKER, B. J., ADGER, W. N. & RUSSEL, D. 2014. Institutional barriers to climate change adaptation in decentralised governance structures: Transport planning in England. *Urban Studies*.

WALT, G., SHIFFMAN, J., SCHNEIDER, H., MURRAY, S. F., BRUGHA, R. & GILSON, L. 2008. 'Doing' health policy analysis: methodological and conceptual reflections and challenges. *Health Policy and Planning,* 23**,** 308-317.

WARDEN, T. 2011. Viral Governance and Mixed Motivations: How and Why U.S. Cities Engaged on the Climate Change Issue, 2005–2007. *In:* HOORNWEG, D., FREIRE, M., LEE, M. J., BHADA-TATA, P. & YUEN, B. (eds.) *Cities and Climate Change: Responding to an Urgent Agenda.* Washington: The World Bank.

WATERS, E., BARNETT, J. & PULESTON, A. 2014. Contrasting perspectives on barriers to adaptation in Australian climate change policy. *Climatic Change,* 124**,** 691-702.

WATTS, S. & STENNER, P. 2005. Doing Q methodology: theory, method and interpretation. *Qualitative Research in Psychology,* 2**,** 67-91.

WATTS, S. & STENNER, P. 2012. *Doing Q Methodological Research: Theory, Method & Interpretation*, SAGE Publications.

WELSH-ASSEMBLY. 2008. *Local Government Partnership Scheme 2008* [Online]. [Accessed 19 May 2012].

WELSH-ASSEMBLY 2010a. Climate Change Strategy for Wales. Visit Wales.

WELSH-ASSEMBLY 2010b. Climate Change Strategy for Wales: Adaptation Delivery Plan. *In:* GOVERNMENT, W. A. (ed.).

WEST, C. C. & GAWITH, M. J. 2005. Measuring Progress: Preparing for Climate Change Through the UK Climate Impacts Programme. UKCIP, Oxford.

WILBY, R. L. & DESSAI, S. 2010. Robust adaptation to climate change. *Weather,* 65**,** 180-185.

WILLIAMS, S. & SCHAEFER, A. 2013. Small and Medium-Sized Enterprises and Sustainability: Managers' Values and Engagement with Environmental and Climate Change Issues. *Business Strategy and the Environment,* 22**,** 173-186.

WILLWAY, T. 2008. *The Effects of Climate Change on Highway Pavements and How to Minimise Them: Technical Report*, Transport Research Laboratory.

WILLWAY, T., REEVES, S. & BALDACHIN, L. 2008. Maintaining Pavements in a Changing Climate. *In:* TRANSPORT, D. F. (ed.). Stationery Office.

WILSON, E. 2006. Adapting to Climate Change at the Local Level: The Spatial Planning Response. *Local Environment,* 11**,** 609-625.

WILSON, E. & PIPER, J. 2010. *Spatial Planning and Climate Change*, Taylor & Francis.

WINTERS, M., FRIESEN, M. C., KOEHOORN, M. & TESCHKE, K. 2007. Utilitarian bicycling: a multilevel analysis of climate and personal influences. *American journal of preventive medicine,* 32**,** 52-58.

WLGA. 2012. *The Welsh Local Government Association (WLGA): about us* [Online]. Available: http://www.wlga.gov.uk/english/about-us/ [Accessed 19 May 2012].

WOLF, J., ALLICE, I. & BELL, T. 2013. Values, climate change, and implications for adaptation: Evidence from two communities in Labrador, Canada. *Global Environmental Change,* 23**,** 548-562.

WORLD-BANK. 2014. *Urban population data* [Online]. Available: http://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS [Accessed 7 November 2014 2014].

WU, J. & WU, T. 2013. Ecological Resilience as a Foundation for Urban Design and Sustainability. *In:* PICKETT, S. T. A., CADENASSO, M. L. & MCGRATH, B. (eds.) *Resilience in Ecology and Urban Design.* Springer Netherlands.

XU, J. & GRUMBINE, R. E. 2014. Building ecosystem resilience for climate change adaptation in the Asian highlands. *Wiley Interdisciplinary Reviews: Climate Change,* 5**,** 709-718.

YANG, Y. & MONTGOMERY, D. 2013. Gaps or bridges in multicultural teacher education: A Q study of attitudes toward student diversity. *Teaching and Teacher Education,* 30**,** 27-37.

YEUN, E. 2005. Attitudes of elderly Korean patients toward death and dying: an application of Q-methodology. *International Journal of Nursing Studies,* 42**,** 871-880.

YIN, R. K. 1993. *Applied Social Research Methods Research,* London, SAGE Publication.

YIN, R. K. 2009. *Case study research : design and methods*, Sage Publications.

ZAINAL, Z. 2007. Case study as a research method. *Jurnal Kemanusiaan***,** 1-6.